MAY 19 1947

Vol. 21 APRIL, 1947 No. 4

SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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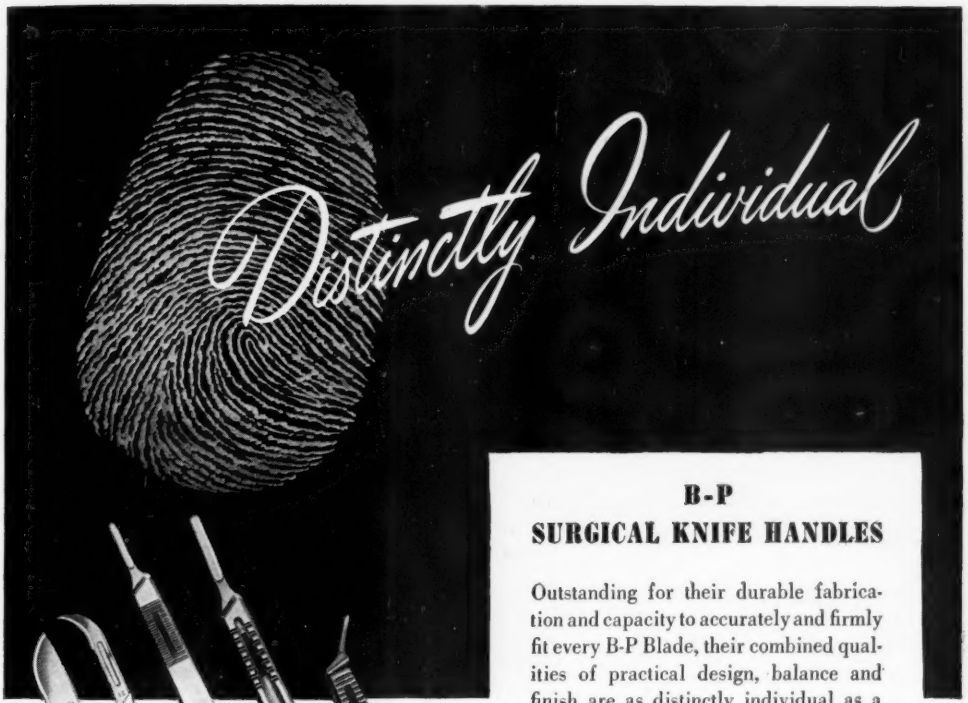

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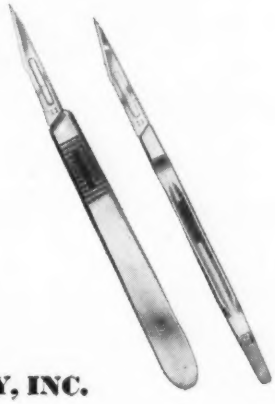

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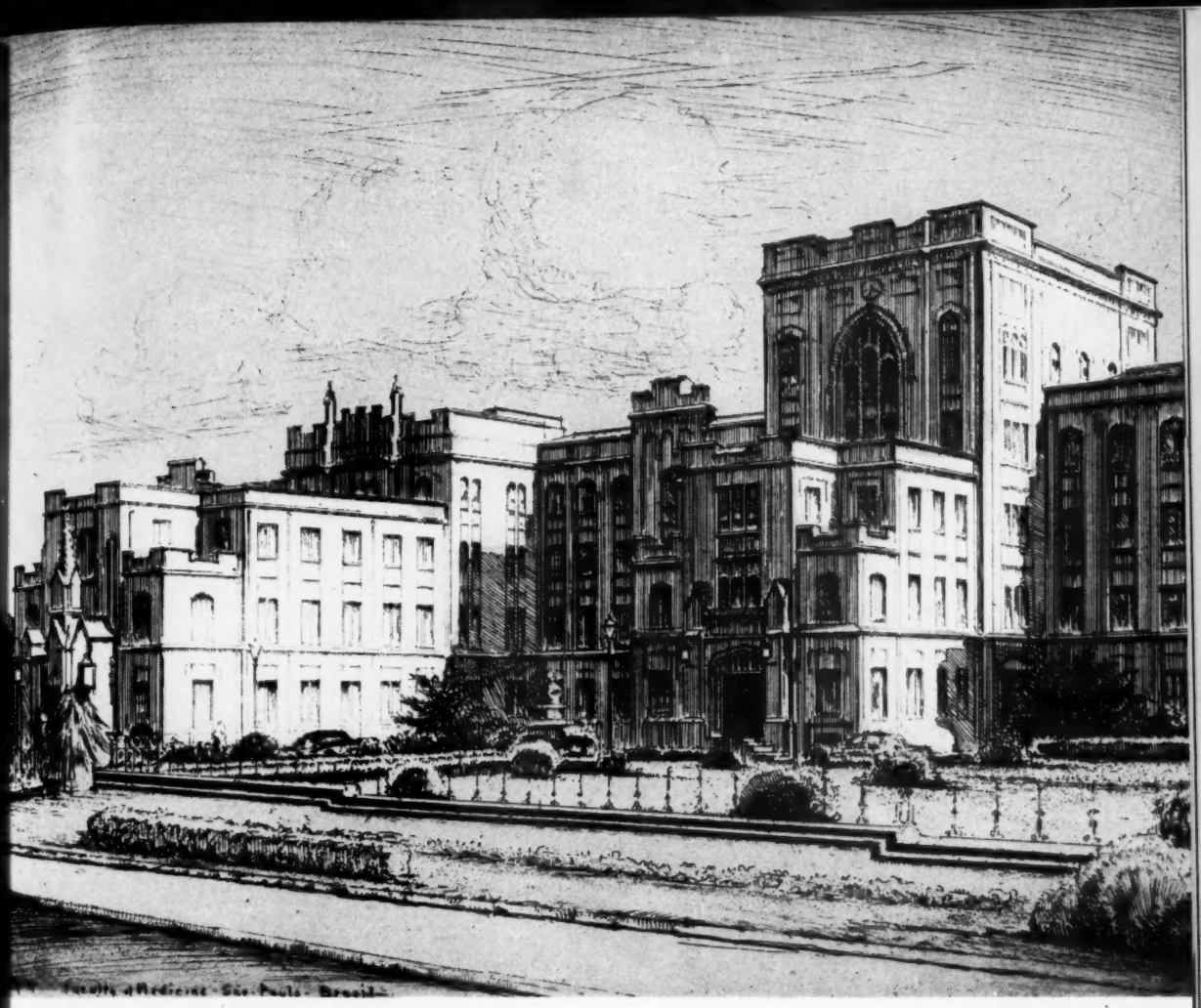

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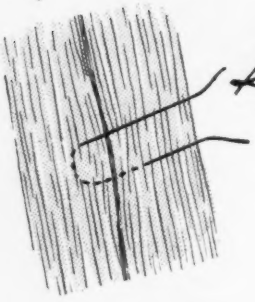
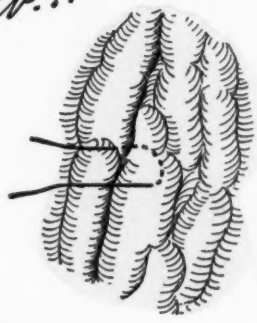
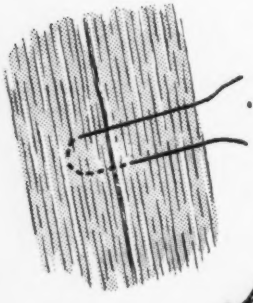
Capacity of tissues to hold sutures



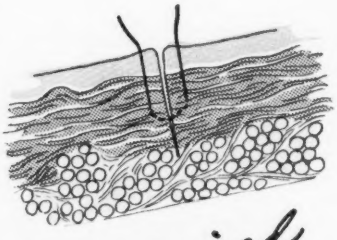
An untied suture pulls out of muscle at ¼ lb...



...fat at ⅛ lb...



...fascia at 8 lbs...



...skin at 10 lbs...

Hence if a strong wound is desired, fascia, the connective tissues and skin should be sutured. Sutures in Muscle and Fat do not contribute strength to the wound. Muscle and Fat should be approximated by suturing their surrounding fascia or connective tissue septae.

SUTUREGRAM

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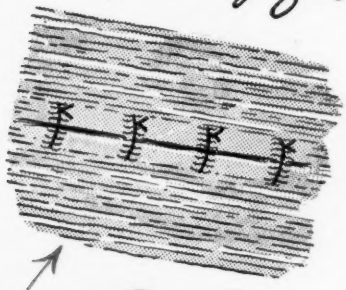
Capacity of tissues to hold sutures

An untied suture pulls out of fascia at 8 lbs against the fibers of fascia

at ½ lb. with the fibers

Consequently the wound is strongest when sutures are placed so they must pull against the fibers of fascia. This is done in 2 ways...

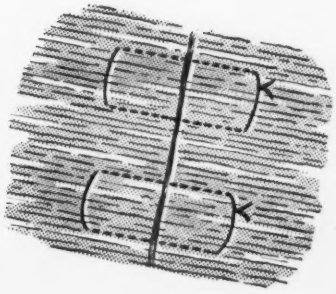


① Wound is made parallel to the fibers of the fascia

or

② If wound divides fibers mattress sutures are used Part of this suture pulls against the fibers

Best



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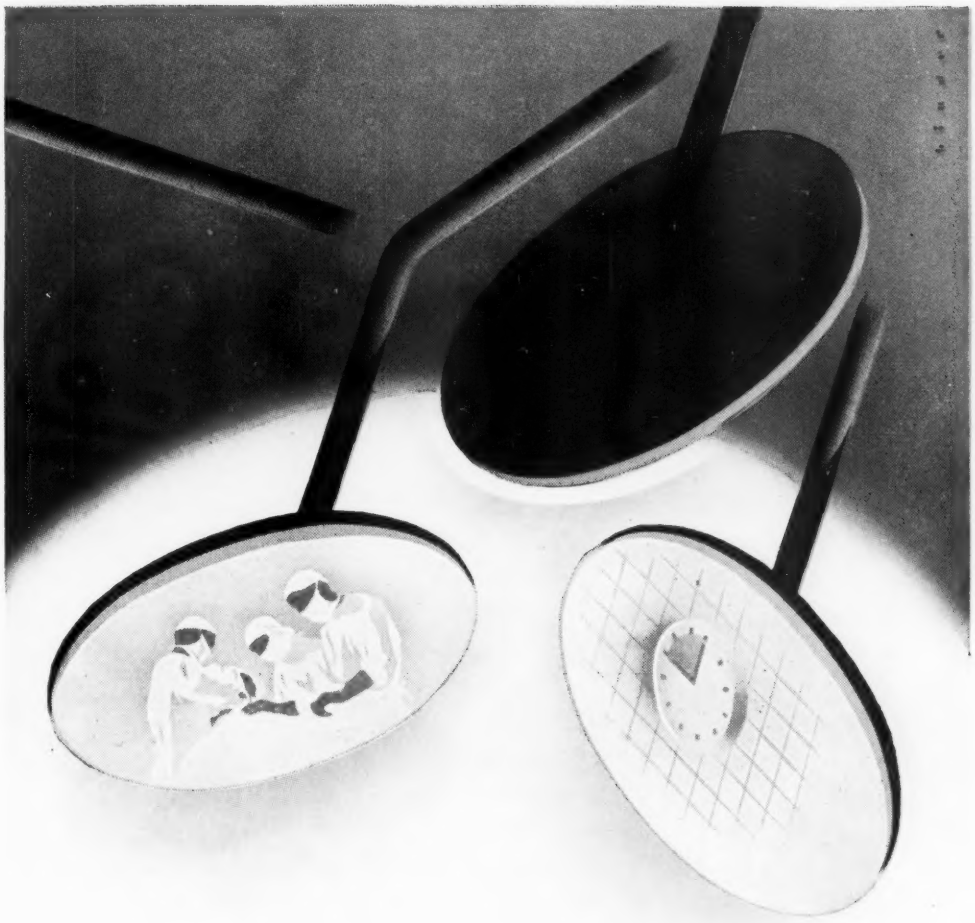

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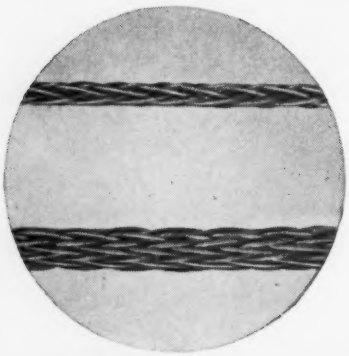

Many individual strands of wire are in Ethicon Braided Tantalum. Photomicrograph, above, shows Sizes 3-0 and 1, magnified to x15.

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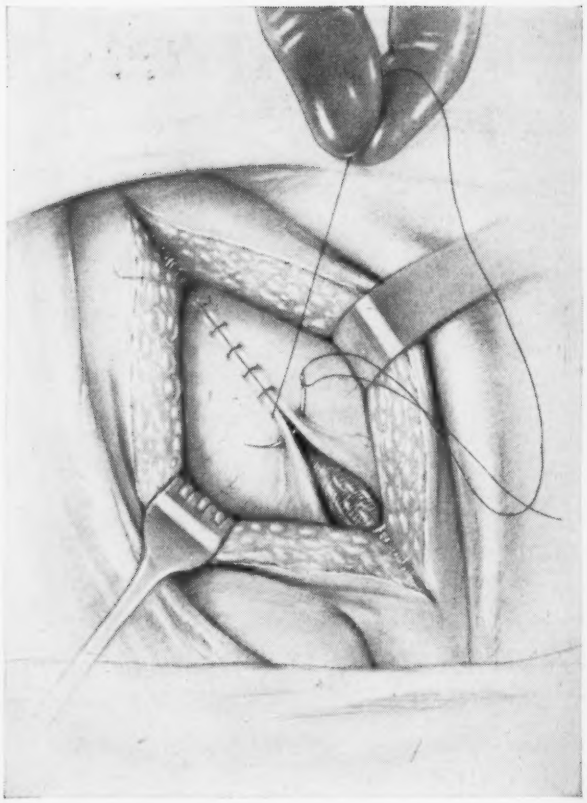

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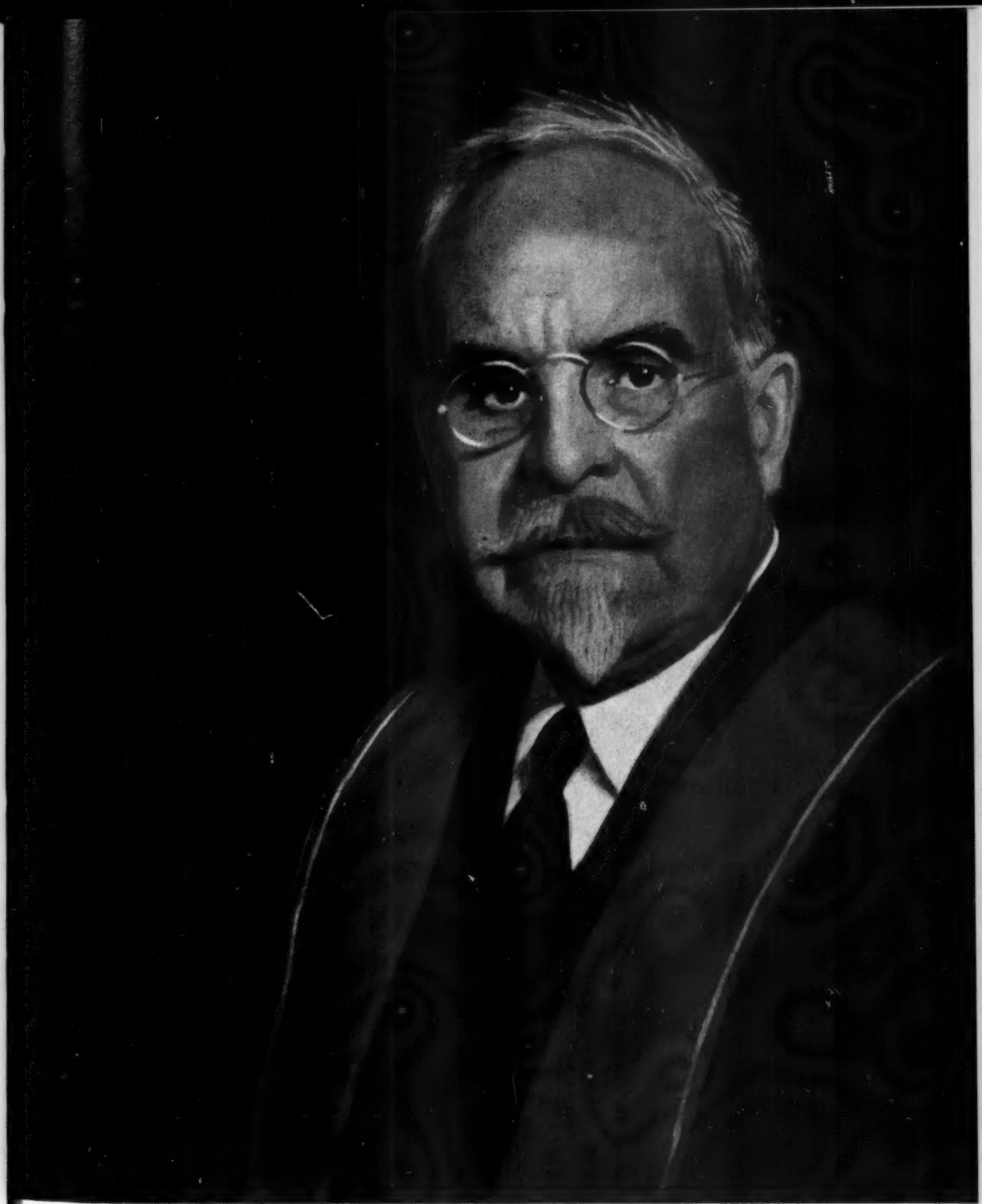

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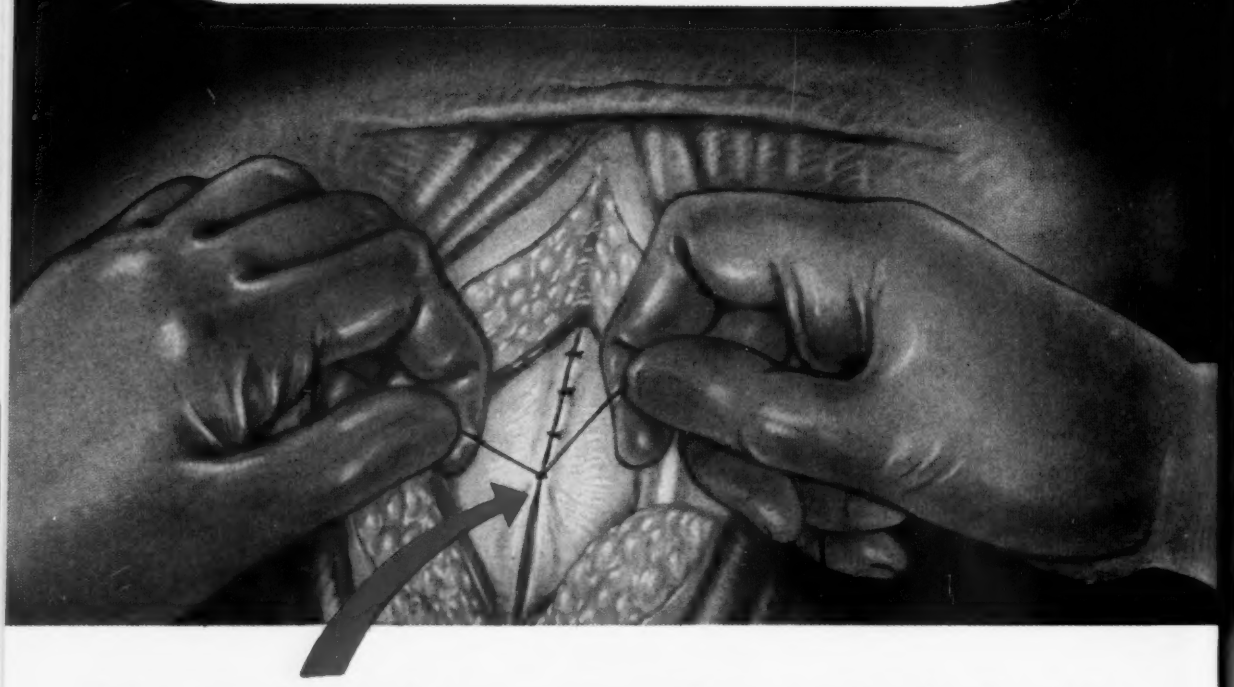

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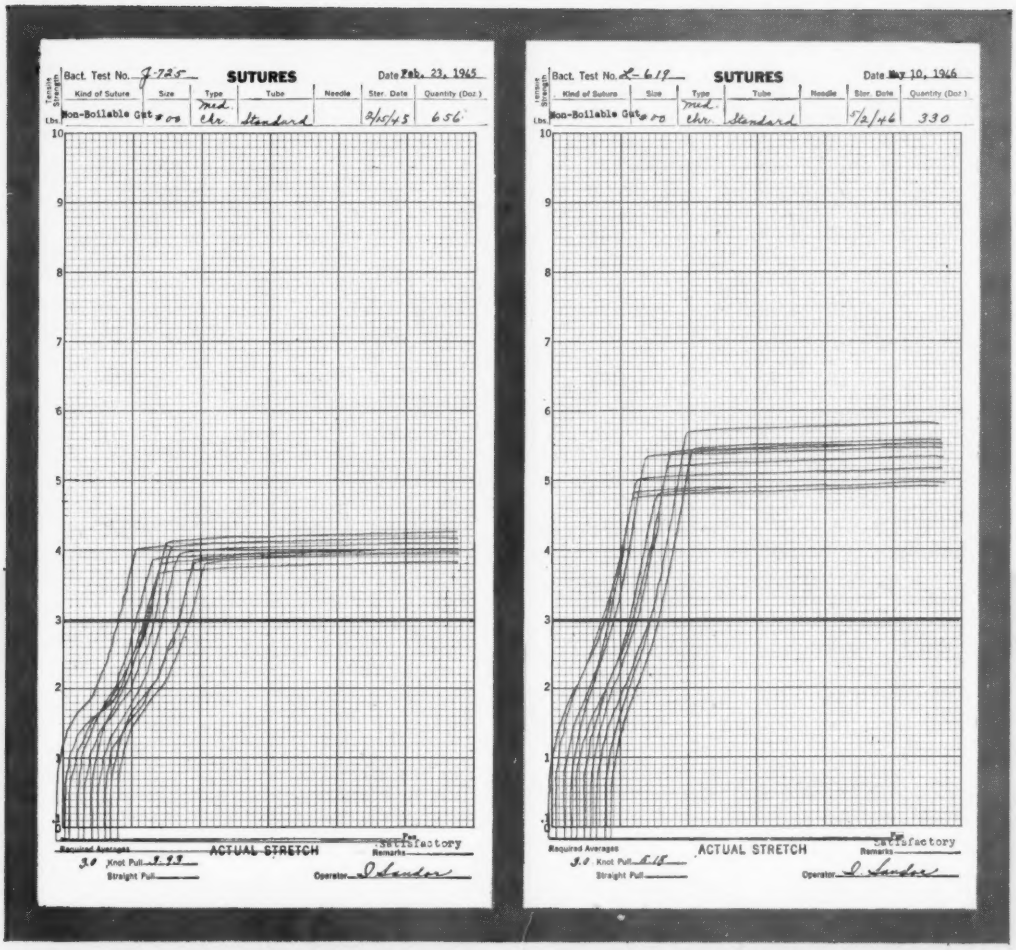

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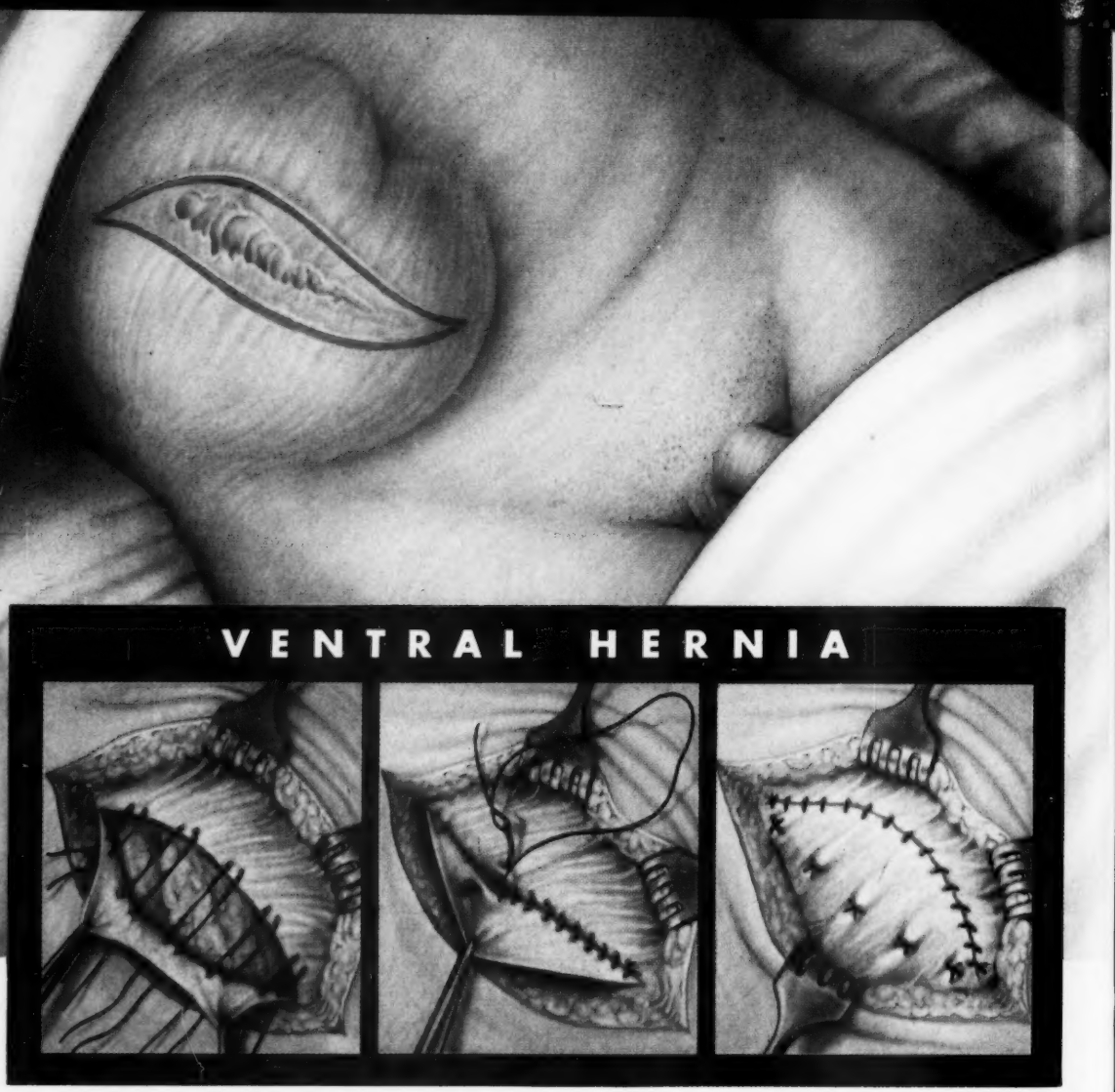

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SURGERY

VOL. 21 APRIL, 1947 No. 4

Original Communications

THE SURGICAL TREATMENT OF ANEURYSMS OF THE ABDOMINAL AORTA

GEZA DE TAKATS, M.D., AND JOHN T. REYNOLDS, M.D., CHICAGO, ILL.

(From the Department of Surgery, University of Illinois College of Medicine, the Research and Educational Hospitals, and St. Luke's Hospital)

WHILE the aneurysms of the abdominal aorta are less frequent (a ratio of 1:7 to 1:10) than those of the thoracic,[1] more than 500 cases have been reported in the literature. Of these, thirty patients have had surgical treatment, the first case being that of Cooper who in 1817 first ligated the abdominal aorta for a left iliofemoral aneurysm with a survival period of three days.[2] During a symposium of the American Surgical Association on aneurysms and vascular surgery, both Bigger[3] and Elkin[4] gave a complete tabulation of all operated cases up to 1940. Matas[5] from his vast experience with aneurysms at all locations reported seven cases, one of which was ligated, three wired, and three simply explored. He also published in detail[6] a report of the successful ligation of a syphilitic abdominal aneurysm in a patient who lived seventeen months and died of pulmonary tuberculosis with a well-obliterated aneurysmal sac and good collateral circulation.

The number of patients who have survived the surgical treatment of these aneurysms by more than one year is only six (Table I). Of these six, cotton tape has been used in five, and fascia lata in one; this is Bigger's successful case in which a second operation was done and an aneurysmorrhaphy was performed. Since this symposium the significant case report of Morton and Scott[7] appeared. In their patient a slowly leaking abdominal aneurysm was treated by two tape ligatures below the origin of the inferior mesenteric artery. A large left retroperitoneal hematoma was found and this may have well interfered with the collateral circulation in the left lower extremity, which subsequently became gangrenous and required amputation at a high level in the thigh. The patient died seven months after ligation of the aorta. A new aneurysm had formed proximal to the ligature which ruptured into the small intestine. The circulation of the right lower extremity was quite satisfactory, the right iliac

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TABLE I. LIGATION OF THE ABDOMINAL AORTA (SURVIVAL MORE THAN ONE YEAR)

CASE NO.	AUTHOR	DATE	SURVIVAL	COMMENT
1	Vaughan	1920	2 yr. 1 mo.	Aneurysm at origin of superior mesenteric artery; partial occlusion at autopsy
2	Watts	1923	3½ yr.	Partial ligation with tape below superior mesenteric artery; death due to rupture
3	Matas	1925	1 yr. 5 mo.	First successful ligation, cotton tape used; patient died of tuberculosis
4	La Roque	1929	14 mo.	Partial occlusion with silk and cotton tape
5	Bigger	1938	2 yr.	Fascia lata above inferior mesenteric artery; endoaneurysmorrhaphy one month later
6	Elkin	1939	11 mo.	Partial occlusion with tape; bruit present

arteries being patent, but the left iliac artery and vein were thrombosed. The post-mortem studies by injection of an opaque substance demonstrated that on the left side (the side of the lost extremity) only the distal part of the hypogastric artery was patent. This was obviously not enough to carry the circulation to the entire lower extremity but nourished the stump of the high thigh amputation.

Wiring of abdominal aneurysms has been practiced for many years. Matas[5] reported three patients, but the outcome is unknown. Wheeler reported a patient who lived eight years after the insertion of Colt's wire.[8] At Johns Hopkins ten syphilitic aneurysms of the abdominal aorta were wired, with only one benefiting from the operation.[9] It is likely wiring has been done in many more cases especially in the past, but there seems to be a dearth of follow-up records in these cases.

Endoaneurysmorrhaphy has been done five times, only once successfully by Bigger.[3] This was in a 25-year-old man with a traumatic aneurysm. Thus, the three methods used to date are partial occlusion proximal to the aneurysmal sac, aneurysmorrhaphy, and wiring with or without a diathermy current. In this paper we wish to present our own experience with this admittedly unsolved problem.

MATERIAL STUDIED

In only two of our eight cases was exploration not done; the first of them was that of a middle-aged obese hypertensive woman who was seen in consultation by one of us (G. de T.) in another hospital. Because of a sudden excruciating pain behind the left shoulder blade, radiating to the abdomen, a diagnosis of acute coronary occlusion was made; consultation was asked because both femoral pulses became unpalpable and both lower extremities became paralyzed. A saddle embolus of the aorta was diagnosed, but because of the patient's critical condition and because the arterial occlusion was of forty-eight hours' duration, no embolectomy was attempted. The patient died within a few hours.

At autopsy (A-550, Mercy Hospital, Jan. 4, 1940) a dissecting aneurysm of the aorta and its major branches was found. Throughout the entire length of the aorta the intima and the internal half of the media were dissected away; in the space thus formed the blood had clotted. The dissection encircled the innominate, the celiac, splenic, both renal, and both common iliac arteries. The

outer tube of clotted blood compressed the inner tube of these arteries, thus producing occlusion. In the region of the rent of the aorta, 3.5 cm. above the aortic valve, atheromas were noted; the outer tube had ruptured into the pericardium which contained at least 300 c.c. of clotted blood.

The second patient was middle-aged, normotensive, nonsyphilitic and had a palpable aneurysm of the abdominal aorta; in addition, one popliteal artery showed a marked saccular aneurysm, whereas the other popliteal artery suddenly became occluded following trauma during a fishing trip. While no mass could be palpated it was thought likely that this occlusion represented an acute traumatic thrombosis of a popliteal aneurysm, which is not infrequently bilateral. The origin of these multiple aneurysms is unclear although a mycotic lesion was suspected by the internist. Exploration had been refused. The patient underwent a cordotomy for the root pain and the abdominal mass steadily enlarged. The patient suddenly died in February, 1946, twenty-two months after the onset of symptoms.

The remaining six patients* were operated upon and their case histories in abstract briefly follow:

CASE REPORTS

CASE 1 (No. 48032 St. Luke's Hospital).—S. K., a 69-year-old farmer, entered the hospital on Oct. 11, 1943, complaining of dizzy spells and a drawing, aching sensation in the abdomen, radiating to the small of the back and into both hips. He noticed a pulsating mass in the lower part of the abdomen.

Past history revealed that since February, 1943, the patient had had repeated attacks of dizzy spells which were relieved by recumbency. At that time he was told of his high blood pressure. Upon arising he felt a tightness in the abdomen and in placing his hand on it he discovered its pulsation. He vomited a few times after the dizzy spells. There was occasional blood in the stools.

On entrance there was a hard pulsating mass 5 cm. long and 3 cm. wide just to the left of the umbilicus. The mass was freely movable, not very tender, and showed a systolic expansion and bruit. Both iliac arteries seemed rather large, particularly the left, so that a second aneurysm here was suspected. The pulsations and oscillometric curves at both ankles were decreased.

On x-ray the thoracic aorta showed no unusual enlargement or calcification. In a lateral roentgenogram of the abdomen a dense deposit of calcium was seen in the wall of the aorta and also in the iliacs. The fourth lumbar vertebra showed some evidence of compression. The blood Wassermann reaction was negative. Blood pressure was 150/96 mm. of mercury which rose to 190/110 mm. of mercury after bilateral iliac compression.

Operation was performed on Oct. 16, 1943, with a diagnosis of abdominal aneurysm of the aorta (G. de T.). The entire abdominal aorta was enlarged, but just below the origin of the inferior mesenteric artery a fusiform aneurysm was encountered extending to the iliac bifurcation. It was the size of a large grapefruit. After the peritoneum was split and the duodenum mobilized, the aorta was encircled above the aneurysm with an inch-wide eight-ply layer of cellophane which was sutured snugly with cotton around the aorta. The operation was done under pantocain-glucose spinal anesthesia. The surgical convalescence was uneventful.

During the postoperative course the patient was re-examined monthly. Eight months after operation the sac was decidedly smaller. He refused a second operation for complete

*One additional patient has been operated on in the Vascular Surgical Unit at the Veterans Hospital, Hines, Ill., by Dr. O. C. Julian. The aneurysm shrank markedly and was palpable only on deep pressure.

ligature over the cellophane band; thirteen months after operation the mass was one-third of its previous size. He again refused operation and returned to Pennsylvania. He died suddenly on December 13, fourteen months after operation, from internal hemorrhage.

The relief from pain and the shrinking of the pulsating mass were striking. Since the iliac arteries were patent and since a partial occlusion of the aorta had undoubtedly been accomplished, an occluding ligature was suggested, but refused. The patient was 70 years old by this time and showed generalized arteriosclerosis. He survived the banding with cellophane for fourteen months.

CASE 2 (No. 57252 St. Luke's Hospital).—W. T., a 55-year-old railroad executive, entered the hospital complaining of severe abdominal pain radiating to the small of the back, of one year's duration.

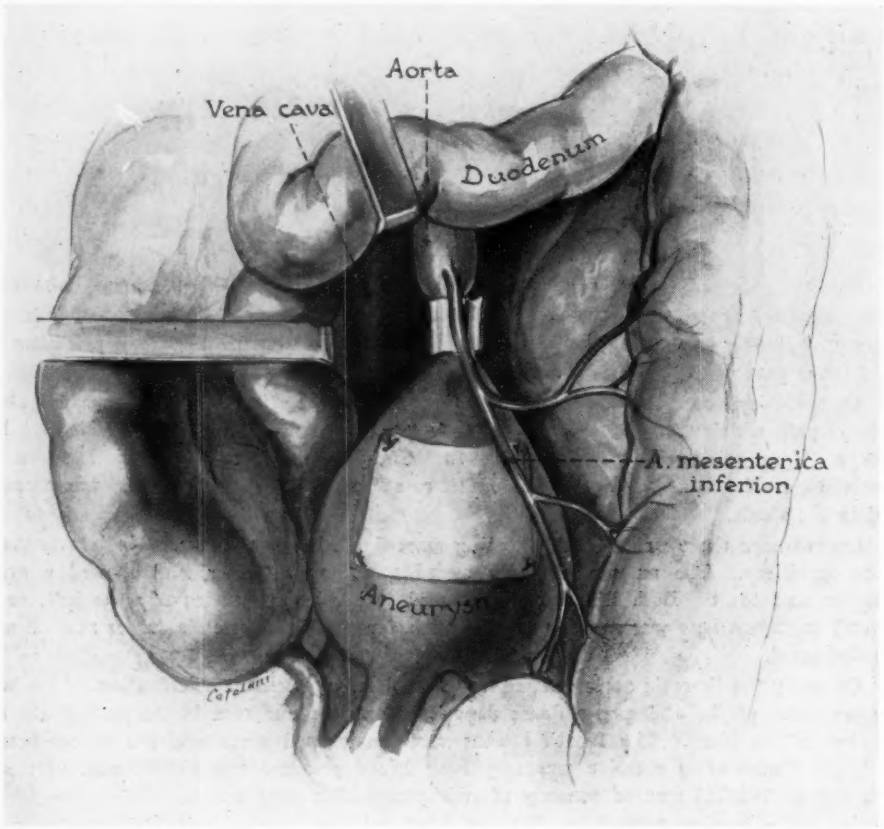

Fig. 1 (Case 2).—Aneurysm of the abdominal aorta. The sac extended from the origin of the inferior mesenteric artery to the iliac bifurcation, but it was possible to separate the inferior mesenteric artery from the sac and place an inch-wide, eight-ply strip of cellophane around the aorta. Over a large, necrotic atheromatous plaque a sheet of eight-ply cellophane was sutured on Dec. 4, 1944.

Past history revealed that he had known of the high blood pressure for several years and was under expert medical care. Three months prior to entrance he was hospitalized and a pulsating abdominal mass discovered. Since that time he had attacks of severe girdle pain which lasted from hours to days. He noticed that the mass was getting larger.

At the time of entrance, blood pressure was 204/110 mm. of mercury. He was slightly deaf and had a parkinsonian tremor. The heart was enlarged to the left with a loud systolic murmur at the apex. There was a visibly pulsating mass in the abdomen to the left of the

umbilicus. The chest roentgenogram revealed a diffuse dilatation of the thoracic aorta. The Wassermann reaction was negative. Stools were negative for blood.

Operation was performed on Dec. 4, 1944, under spinal anesthesia with pantocain-glucose (G. de T.). A saccular aneurysm of the abdominal aorta was found extending from just below the inferior mesenteric artery to the bifurcation of the iliacs. On the summit of this sac was a greenish, partly necrotic aortic plaque which rose with each pulsation and whose extrusion seemed imminent. Wiring of this sac did not seem justifiable. An eight-ply layer of cellophane was wrapped around the aorta proximal to the sac and also around the anterior surface of the sac (Fig. 1). The sac could not be encircled posteriorly, since it was firmly fixed to the spinal column. The cellophane was covered with the root of the mesentery and the omentum. The loops of small bowel which were adherent to the sac were disturbed as little as possible. The patient's pressure fell twice during the operation but could be readily restored with neosynephrin.

During the postoperative course the thiocyanate level was maintained at therapeutic levels. Three months after operation the blood pressure was 210/130 mm. of mercury. The mass was one-third of its previous size. All abdominal pain had disappeared. The patient returned to work. At nine months the mass was quite hard, still receding. It seemed close to the abdominal wall. There were no symptoms. Blood pressure was 230/140 mm. of mercury. At fourteen months there were no symptoms and he was working a full day. The cellophane created a hard, turret-shaped mass over the threatening perforation and could be well palpated through the abdomen.*

CASE 3 (No. 307205 Research and Educational Hospitals).—W. McC., a 57-year-old white man, was well until six months before entrance, at which time he noticed a moderately severe pain in the left lumbar region which was severe enough to disable him for four days and require a hypodermic for sedation. The pain was constant and aching in character. The following four months the patient had no complaints. Two months prior to admission the patient had a recurrence of severe aching pain which sometimes appeared to be referred to the left groin and testicle. For relief from this pain the patient went to Cook County Hospital and here x-ray views revealed the presence of a mass outside the bowel in the abdomen which was consistent with an intra-abdominal or retroperitoneal mass; the pyelograms were normal and fluoroscopy of the abdomen showed some calcified plaques about the tumor mass but no erosion of the anterior vertebral bodies. In the two months before admission the patient had noted presence of this mass in the left side of the abdomen and had noted that it pulsated but he had not noted any marked change in the size of the mass. During these two months the patient had had some weight loss which he attributed to anorexia during the periods when the pain was severe. He had also been suffering from some orthopnea and had dyspnea on mild exertion lately.

On entrance, physical examination revealed mild orthopnea, a blood pressure of 130/100 mm. of mercury, a heart enlarged to the left, a pulse rate of 76, a thrill over the precordial area, a rasping thrill over the aortic arch, and a loud systolic murmur over the aortic ring. In the left side of the abdomen opposite the umbilicus was a mass about the size of a grapefruit which was hard but compressible and which was slightly tender to palpation. The mass though pulsating was hard to call definitely expansile. An electrocardiogram showed left axis deviation, ventricular extrasystoles, and signs of left ventricular hypertrophy. Spinal Wassermann was normal. Examination of the chest showed generalized increased bronchovascular markings, moderate enlargement of the left ventricle with diffuse dilatation, and tortuosity of the aorta. The lower third of the esophagus was displaced anteriorly and to the right by diffuse enlargement of the thoracic aorta. Intravenous pyelograms showed a moderate degree of lateral displacement of the left ureter which might be due to pressure from an abdominal aneurysm. An irregular calcified mass was also noted in the abdomen overlying the left psoas muscle which was not of definitely determined origin.

*Two years after operation the patient died with a growing mass in the upper part of the abdomen. Autopsy was not permitted.

On July 5, 1945, because of the age of the patient and the feeling that gradual stenosis of the aorta was the only safe way to handle what was felt to be an aneurysm of the abdominal aorta, under spinal and supplementary anesthesia the aorta was dissected free by opening the lesser parietal cavity, reflecting the pancreas upward, and separating the left renal vein from the aorta (J. T. R.). Dissecting between the vena cava and the aorta, the aorta was encircled by four thicknesses of three-quarter inch wide cellophane twice proximal to the aneurysmal dilatation. It was the impression that this was done distal to the renal vessels though these were not dissected out, since it was felt that the small occlusion that would ensue would promote development of collateral circulation through the branches of the celiac if necessary. The postoperative course of the patient was uneventful except for some pain immediately following surgery.

The patient was contacted by telephone on Aug. 23, 1945, at which time he had no more pain in the abdominal mass but a great deal of pain in the small of the back which

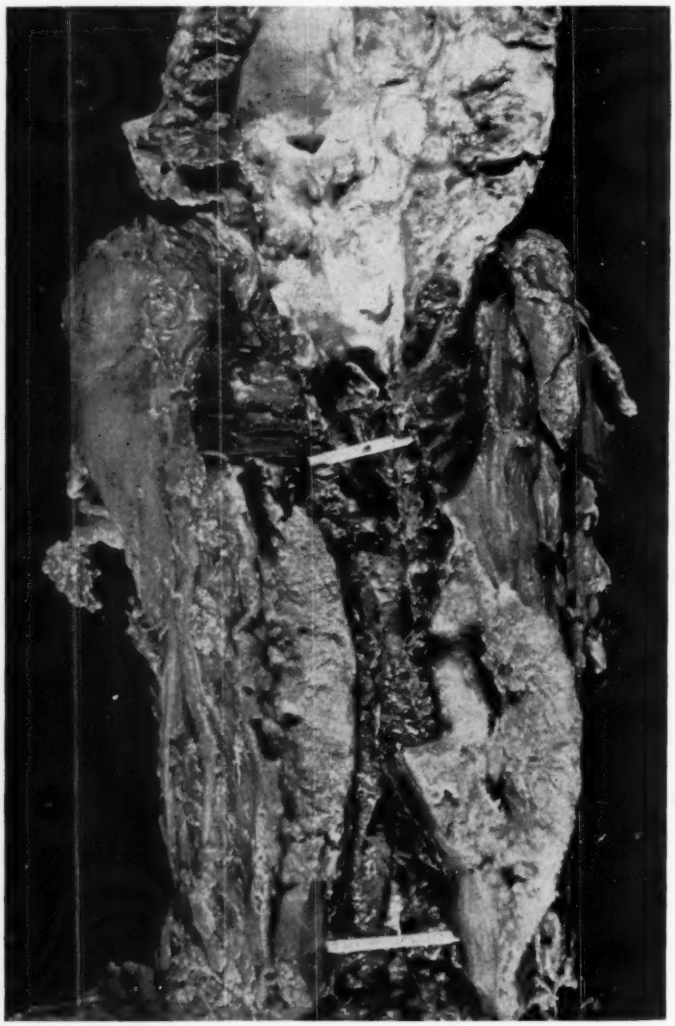

Fig. 2 (Case 3).—Aneurysm of the abdominal aorta; specimen obtained at autopsy. Note the widened aorta with calcified plaques with a sudden increase in diameter. The cellophane band is partly visible at the level of the small wooden peg. There is a narrow central lumen, lined with a partially organized mural thrombus which in turn is surrounded by a thick, calcified, partly atheromatous wall. The lesion extended to the iliac bifurcation which is beyond the bottom of the picture.

did not appear to be quite explicable. The mass in the abdomen had not increased any in size and the original pain associated with the development of the mass was not present.

He was re-admitted to Research and Educational Hospitals on Feb. 5, 1946, because of a steadily increasing pain and loss of weight. He was steadily going downhill. He had started vomiting blood at intervals and had tarry stools. The respiratory distress increased and he expired on March 14, 1946, approximately one year after the onset of symptoms.

Autopsy (A-44 of 1946) revealed a greatly enlarged heart with a complete occlusion of the left descending branch of the coronary artery. The thoracic and abdominal aorta contained many calcified plaques. The abdominal aorta from the diaphragm to the iliac bifurcation was greatly dilated measuring 9 cm. in external diameter. Approximately 13 cm. above the bifurcation of the aorta a cellophane band surrounded the aorta. Anteriorly this 1.5 cm. wide band was imbedded in fibrous tissue, but posteriorly it lay free between the aorta and the vertebral column. There were large intramural pockets of atheromatous material and the calcified inner layers were brittle. The lumen of the aorta was partially occluded by a thick laminated layer of organized blood, leaving a central tube approximately the width of a normal aorta. The renal arteries were patent, the superior mesenteric artery and the celiac axis were demonstrable, but the inferior mesenteric artery could not be located (Fig. 2).

There was a shallow transverse erosion of the second lumbar vertebra, explaining the high root pain. The aorta did not appear constricted at the region of the cellophane band. The tissues around the band, however, were markedly fibrosed and infiltrated by inflammatory cells. A sinus tract extended from the cellophane band into a blind pocket of dense fibrous tissue. This was lined with granulation tissue showing marked inflammation. Macrophages containing black and yellow material were numerous in the sections.

Death was ascribed to myocardial failure due to coronary insufficiency and complicated by bronchopneumonia. Chronic passive hyperemia was found in the lungs and liver.

Comment.—This patient certainly seemed past the stage of operability; both the thoracic and aorta were involved. The rigidity of the dilated aorta and the extent of the lesion made this therapeutic attempt rather hopeless. It is interesting that the occlusion of the inferior mesenteric artery, which no doubt was gradual, could be tolerated.[11] The findings at autopsy showed that the patient had cured the aneurysm by thrombotic occlusion and central canalization but the adjuvant role of the cellophane in this process must be considered as highly doubtful. While fibrosis was produced, this could hardly have been sufficient to produce partial occlusion of the aorta.

CASE 4.—M. H., a 54-year-old colored laborer, was well until July, 1943, when "lightning-like chest pains" encircling the lower end of the chest appeared. In December, 1943, with a diagnosis of syphilitic aneurysm of the abdominal aorta, the sac was wired through a laparotomy at Cook County Hospital (J. T. R.). The patient improved for six months after which recurrence of pain led to a second wiring through the left lumbar region into which the pulsating mass had protruded in July, 1944. This again led to some relief, but in November, 1945, because of intractable root pain, a high cordotomy was performed at the Neurological Institute of the University. He died in the next twenty-four hours. Autopsy could not be obtained.

CASE 5 (No. 263645 Research and Educational Hospital).—R. B., a 52-year-old white man, was admitted on Feb. 6, 1941, complaining of a swollen, ulcerated left leg for the past ten years; swelling in the left groin of three years' duration.

Past history revealed that in 1930 he had injured the left ankle, eventually resulting in an ulcer of the left leg which had remained for the past ten years. He first received local treatment but in 1933 the ulcer was diagnosed as syphilitic. The patient was told he had syphilis. About two years before, he had noticed a mass present in the left lower quadrant with associated pain.

On entrance, physical examination revealed a well-developed, well-nourished Mexican man, 52 years old, lying comfortably in bed. Heart rate was 64, rhythm regular; ½ inch enlargement of the heart to the left. A soft, systolic murmur was heard in the apex. Blood pressure was 115/70. The lungs were negative. A mass was found in the left lower quadrant of the abdomen directly above the symphysis and extending bilaterally to both inguinal regions; both masses pulsated with the heartbeat; bruit was present over the mass. The left leg was enlarged, the thigh was indurated; a large ulcerated area was present in the lower left leg. Edema of the left foot was also present. Compression of the mass above Poupart's ligament caused a bradycardia, slowing of rate from 76 to 60, therefore it was thought that the communication was between the region of the femoral and iliac junction. Spinal fluid was clear; urine negative; red count on admission was 4.4; white count, 4.1; hemoglobin, 10. Serology was positive; blood chemistry essentially normal at all times.

Exploratory laparotomy was done on Feb. 18, 1941 (G. de T.). Left rectus incision was made below the umbilicus. A large retroperitoneal grapefruit-sized pulsating mass presented itself when the peritoneal cavity was opened. The common iliac artery was extremely dilated and a large aneurysmal sac was present; this sac also involved a portion of the terminal aorta. The exact extent of this involvement could not be determined, therefore no ligation was attempted. The inferior mesenteric artery was involved in the mass. It was felt that the lesion was inoperable and closure was made in layers.

The postoperative course was seemingly uneventful with good healing of the wound until the thirteenth postoperative day, at which time the patient suddenly expired due to the rupture of the aneurysm.

This diagnosis was subsequently verified by autopsy, the diagnosis being rupture of varix of left external and internal iliac veins on the basis of an arteriovenous aneurysm; hemoperitoneum; syphilitic aortitis; fusiform aneurysm of the aorta; fusiform aneurysm of the left common internal and external iliac arteries.

Comment.—This was an unusual case, since the syphilitic abdominal aneurysm of the aorta must have eroded first into the left common iliac vein. An arteriovenous fistula on a syphilitic basis has not been found in the literature available to us. The case was obviously inoperable.

Case 6.—C. S., a 54-year-old colored laborer, entered the Research and Educational Hospitals as an emergency case on Sept. 27, 1945.

Past history revealed that he had had pain in the epigastrium since 1941. A hard, pulsating mass was discovered high in the abdomen in the same year. He was known to have had syphilis and had had adequate treatment.

On entrance to the hospital the patient was in excruciating pain. He was cold and clammy and blood pressure was 90/50 mm. of mercury. There was a huge pulsating mass filling the entire abdomen. The left lower extremity was cold, pulseless, and greatly swollen. It was felt that the aneurysm was leaking around the iliac bifurcation, occluding both the iliac artery and vein. The nonprotein nitrogen was 49 mg. per cent.

The patient slowly improved on bed rest and parenteral feeding. The swelling improved somewhat and the femoral arterial pulsation reappeared but no pulsations were present at the popliteal arteries. The foot remained in a precarious position. On Oct. 9, 1945, two weeks after entrance, exploration was done under spinal anesthesia (G. de T.). The aneurysm extended from the celiac axis to the iliac bifurcation and occluded the left common iliac vein. The left common iliac artery was patent but there was considerable mural thrombosis in the main sac which must have thrown a shower into the left lower extremity. The abdomen was closed since the case was judged inoperable.

Follow-up study showed that there was progressive caval obstruction. Both legs began to swell and the scrotum became edematous. A telephone call received two months later revealed that the patient was repeatedly tapped for ascites indicating obstruction in the portal system. He died at home.

Comment.—This, too, was an inoperable case, and it is interesting to note that the mass had been discovered four years previously. The man had been in fair health until his emergency entrance to the hospital.

DISCUSSION

Of the six cases presented, we were able to use cellophane in three, although one patient (Case 3) might be regarded as being beyond help. Of the three patients banded with cellophane, two survived the one-year limit, and the third patient lived for eight months. From Bigger's statistics we can gather that 87 per cent of patients suffering from abdominal aneurysms die in less than one year after the onset of symptoms, and from Table I it can be seen that only six patients have so far survived the operation more than one year. In the case of Matas, the patient was febrile and bedridden because of pulmonary tuberculosis. The blood pressure was quite low. This may have facilitated the clotting of the sac. In Bigger's case, the patient was a young man with an intact cardiovascular apparatus, so that a two-stage aneurysmorrhaphy could be performed. We mention this not to detract from the beautiful result in these cases but to emphasize the difficulty of dealing with the hypertensive and syphilitic groups, with so much degeneration in the peripheral vascular tree.

Of the two cases in which a collar of cellophane was wrapped below the origin of the inferior mesenteric artery, one patient died of a ruptured aneurysm fourteen months later; since the sac never stopped pulsating it is reasonable to assume that the sac ruptured and not the aorta above the band. The other patient who is living and well should have a second ligature applied on top of the cellophane band although it is doubtful whether the hypertensive heart will stand the strain. One of Bigger's patients died of a left heart failure after ligating the aorta and it is to be noted that sudden compression of both iliac arteries raised the blood pressure in the patient (Case 1) from 150/96 mm. to 190/110 mm. of mercury. Such a sudden rise may put a dangerous strain on a vascular apparatus which is atheromatous or sclerotic.

Because of this and because of the obviously meager collateral circulation which exists in acute aortic occlusion, the cellophane wrap seems especially useful. Page[12] used cellophane to produce experimental renal hypertension in dogs by causing a thick perirenal fibrosis. Pearse[13] succeeded in producing a gradual, complete occlusion of the aorta of dogs. While no external compression was used, three dogs died of a rupture of the aorta but in a few a complete occlusion took place. It is not clear how many complete or partial occlusions were obtained, but in a later statement Pearse[14] said that in later experiments a large number showed no response. He suspected that there is some substance in the cellophane the presence or absence of which determines the amount of fibroplasia produced.*

In man, Harrison and Chandy[15] wrapped cellophane proximally and distally of a subclavian aneurysm in two Arabs. One of these was successful, the com-

*Since this article was submitted for publication, the paper of Poppe and de Oliveira (J. Thoracic Surg. 15: 186, 1946) has advocated the use of polythene cellophane for the wrapping of syphilitic thoracic aneurysms. They felt that other varieties of cellophane produce no fibrosis.

plete occlusion taking nineteen months. They suggested the use of this substance for gradual occlusion in aneurysms of the aorta. That gradual closure of the aorta, especially at its lower end just above the iliac bifurcation, is tolerated is best exemplified by a goodly number of patients whom we have seen with saddle thrombosis developing slowly at the site of atheromatous plaques. While such patients have claudication and complain of loss of penile erection and ejaculation, the viability of the limbs is maintained. In doing lumbar sympathectomies for such a group, the size of the lumbar arteries, serving as

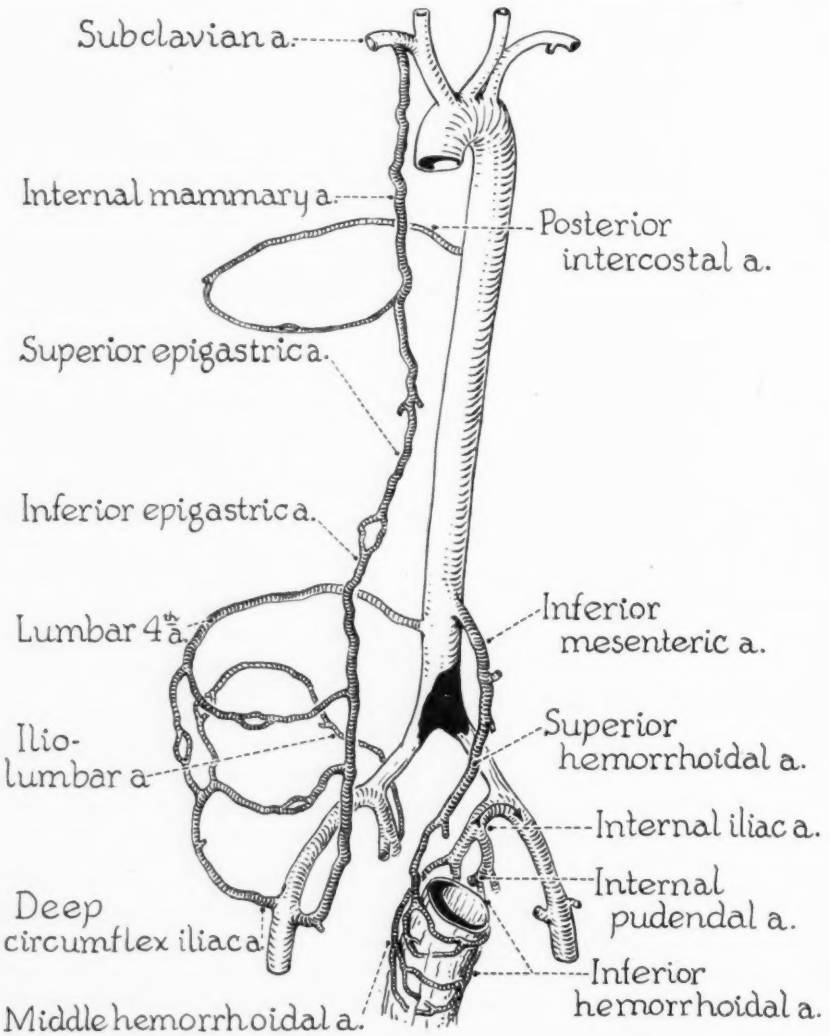

Fig. 3.—Diagram of collateral circulation in slow occlusion (gradual saddle thrombus) of the aorta. The first pathway through the internal mammary is active only in high aortic occlusions as in coarctation of the aorta but in low occlusions may play only a secondary role. The anastomoses of the branches of the superior hemorrhoidal, with the middle and inferior hemorrhoidal vessels, and from them to the internal iliac artery may be palpated occasionally as pulsating vessels through the rectal wall. The most important vessels are the intervertebral (intercostal and lumbar) arteries, of which only one is shown, as they connect through the iliolumbar to the internal iliac and through the deep circumflex to the external iliac arteries. On the integrity of these pathways depends the viability of the limb; a large sac or a dissecting hematoma may interfere seriously with this network. Placing a partially constricting band *just below* a pair of lumbar arteries stimulates their enlargement.

collaterals, is very obvious. In the accompanying diagram (Fig. 3) we show the available channels, all of which require the integrity of the external iliac and the lower part of the internal iliac artery. In the injection specimen of Morton and Scott,[7] obtained at autopsy, one can see the great importance of the patency of the iliac arteries. Whether the lumbar arteries function or not will depend, of course, upon how many of them are involved in the intrasaccular thrombus.

The use of cotton tape, which has been the most successful material for producing partial occlusion, still suffers from one defect common to all methods producing occlusion from the outside: namely, that partial or complete occlusion of a large artery by compression always leads to the death of the vessel wall.[16] The multiple, rubber-band occlusion of Owings and Hewitt[17] has been put to a clinical test by Monahan,[18] who ligated the abdominal aorta proximal to a syphilitic aneurysm in three stages; he was able to obliterate the sac, but five months after the first ligature the aorta perforated just proximal to the highest rubber band into the third portion of the duodenum. The patient also seemed to have persistent pain and coldness in the right leg after the second ligature.

It has become increasingly obvious to us that in the presence of these degenerative lesions of the aorta, especially in the presence of hypertension, a complete ligature in continuity will not be tolerated for any length of time. There remain other possibilities: either the production of slow fibrosis with nonconstricting application of cellophane, followed later by wiring; the complete excision of the sac with transection of the aorta: a heroic procedure, but safer from the standpoint of proximal rupture than the occlusion in continuity, and finally a combination of proximal banding with a partial wrap of cellophane around the sac, a procedure which is simple and has been carried out in Case 2. In this one case no intestinal obstruction has been encountered after a follow-up of fourteen months. The cellophane must be guarded jealously from contact with the free peritoneal cavity. However, this risk is small if a good fibrous wall can be built up around the weak portion of the aneurysm. There is also a good possibility that the inflammatory reaction produced in the vessel wall will reach the intima and favor mural thrombosis, which is a self-healing process in aneurysmal sacs, as seen in Case 3.

SUMMARY

A group of eight aneurysms of the abdominal aorta have been observed. Of these, two were not operated on, two were simply explored, one was wired, and three were banded with cellophane. Of this group only the three treated with cellophane wrap survived for any length of time. One patient lived fourteen months, another died after eight months, and the third, whose sac had also been wrapped in addition to a proximal cellophane collar, is doing well at this writing.

ADDENDUM

Since this article went to press, it became obvious that the type of cellophane used may be the deciding factor in the production of adequate fibrosis. For this reason in a recent case, not included in this series, strips of cellophane were implanted into subcutaneous pockets to study the reaction of the connective tissue of the patient, whose aneurysm was to be wrapped in cellophane.

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RESECTION OF PRIMARY LIVER TUMORS

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SURGICAL removal of large masses of liver tissue has always presented a formidable problem. The chief concerns of the surgeon have been, first, the question of how much liver could be removed without seriously disturbing the function of that organ; and second, the necessity for adequate control of hemorrhage.

Recent advances in knowledge of the physiology of the liver, and gradual accumulation of clinical data from reports of surgical cases, have fairly well eliminated the fear of producing liver insufficiency by removal of large portions. Fishback[1, 2] and others have shown experimentally that four-fifths of the liver of animals may be safely removed. The remarkable regenerative capacity of the liver partially destroyed by disease processes, as in cirrhosis, is well known. Important clinical observations include such studies as those by Turner,[3] in 1923, who found liver function normal after removal of an adenoma weighing two pounds, three ounces; and by Pickrell and Clay,[4] who removed the entire left lobe in three patients, subsequently finding liver function normal in two, and only slight retention of bromsulfalein in the third.

Of probable significance in the regenerative capacity of the liver is the rich arterial blood supply to all parts. The right and left branches of the hepatic artery anastomose freely so that if either main branch is divided during the course of a resection, the intact branch can adequately supply the remaining portions of the liver (Martens[5]). Although the vascularity of the liver is in one sense unfortunate from the surgical viewpoint, it is at the same time favorable to the removal of any particular part of the liver without jeopardizing nutrition of the remainder. However, extreme care must be taken to avoid damage to the main hepatic artery. Even temporary compression of the hepatic artery produces symptoms of shock, and this method of control of hemorrhage from the liver substance is consequently unsuitable. After radical operations for advanced carcinoma of the extrahepatic bile ducts, Brunschwig and Bigelow[6] reported autopsy findings, including extensive liver infarcts resulting from damage to the hepatic artery.

Control of hemorrhage is still the primary difficulty in liver surgery. Many methods have been used with varying degrees of success. Early resections, as reported by von Eiselberg[7] in 1893, and von Rosenthal[8] in 1897, were done with the cautery to aid hemostasis, and the cut surfaces were packed with gauze, which was later removed. In 1899, Keen[9] resected the left lobe of the liver for carcinoma, burning through the pedicle with a cautery, ligating the larger vessels, and closing the open part with catgut sutures and a gauze pack. Keen

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reviewed seventy-six previously reported cases of resection of liver tumors. Shumacher,[10] in 1942, removed an angioma of the left lobe using Kelly clamps, cautery, and sutures. He reviewed fifty-six resections for angioma of the liver. Pickrell and Clay, in 1944, reported three cases of resection of the left lobe of the liver. Otherwise, only single cases have been reported.

The method for controlling hemorrhage described by Pickrell and Clay has been used by us satisfactorily in operations on three patients with liver tumors. The essential feature of this technique is the use of a line of interlocking mattress sutures passing through the liver substance proximal to the line of incision in the liver. These are placed prior to the incising of the liver, for the purpose of immediate control of bleeding by compression. In all three, the tumors were hepatomas, liver cell tumors of low-grade malignancy. The first patient, a man of 73 years who is alive and well after twenty-two months, had a resection of the entire left lobe, as in all three cases reported by Pickrell and Clay. As these authors indicated, resection of the left lobe proved to be easier technically than resections of portions of the right lobe. In our second case, a child 3 years of age, a huge tumor of the left lobe invading the right lobe, was successfully resected, but the patient died six months later with recurrence of the tumor. Packard and Stevenson[11] reported an almost identical one. Our third patient, a child 20 months of age, had a much smaller tumor of the right lobe, and had a much more favorable prognosis.

CASE REPORTS

CASE 1.—L. K. K., a white man, aged 73 years, was admitted to Baylor University Hospital, May 27, 1944, complaining of occasional nausea and vomiting with severe pain in the left upper abdomen of four months' duration; frequent belching after meals; and nocturia, one or two times, for several years.

Present Illness.—The onset was sudden, some time in January, 1944. The patient became nauseated and vomited following the eating of fresh tomatoes. He thought he had "ptomaine poisoning." At the same time, he had a cramping in the epigastrium and noted "rolling movements" and "rumbling" in the abdomen. On feeling the abdomen, the patient noted for the first time a hard lump in the upper abdomen. This mass grew slowly after he first noticed it, and on admission was about twice its original size. No other pain or tenderness was noticed except that occasionally, at frequent intervals (one or two days), a sharp pain beginning in the area of the mass radiated into the left side of the chest and neck. The patient stated that he could move the mass freely. The indigestion continued, and he belched frequently. Bowels moved regularly; there were no clay-colored or tarry stools, and no jaundice.

Past History.—Questioning showed the cardiovascular system negative, and the respiratory system negative, except for pneumonia seven times during his life, without recurrence in the past fifteen years. There was no additional history of chest pain. Gastrointestinal system was negative, until the present illness. In the genitourinary system, there was nocturia one to two times; no day frequency, burning, or urgency. Extremities were negative. He had fracture of the left clavicle eighteen years before.

The patient led the active outdoor life of a farmer. Fifty years before, he had been bitten by a tarantula on the left cheek. This was followed by marked swelling of the face, which was treated by multiple incisions. Since that time, he had paralysis of the lower left side of the face.

Family History.—The patient did not remember about grandparents, but both mother and father died of "heart disease." Two brothers and a sister were living.

Physical Examination.—Examination revealed a well-nourished, well-developed elderly man, with Bell's Palsy of the left side of the face, lying quietly in bed, not acutely ill. Pulse was 90; respiration, 20; temperature, 98.6° F. The head showed paralysis of muscles of the left side of the face below the forehead. Pupils reacted to light and accommodation, but he was unable to close the left eyelids; the left conjunctiva was red and inflamed. Ears and nose were negative. The neck had no masses, no Virchow's node, no visible venous pulsations. The thyroid was not enlarged. The chest had equal expansion. There was no interspace retraction or disturbance of vocal or tactile fremitus. Breath sounds were undisturbed, there were no râles, and percussion was not abnormal. By percussion of the heart the border was found 7 cm. to the left of the midsternal line; there were no murmurs or arrhythmia. Blood pressure was 150/75. In the abdomen there was a large visible and palpable mass in the left upper part, measuring 5½ by 7½ cm. on the surface. This mass was hard and freely movable, moving with respiration; it was not attached to the costal margin or the skin, but appeared to be attached to the liver. There was no tenderness or tympany, no other masses or scars. Extremities were negative. There were no lymph nodes in the axillae or inguinal areas. Reflexes were physiologic.

Laboratory Studies.—Urinalyses on May 30, 1944, were negative except for 20 mg. albumin and a few white blood cells. June 5, 1944, they were essentially normal and also on June 13, 1944. Blood chemistry was as follows: May 31, 1944, urea, 19.3; urea nitrogen, 9.0; sugar, 95 mg. per 100 c.c. of blood; chlorides, 420; plasma proteins, 5.8. June 8, 1944, plasma proteins, 4.5; albumin, 2.5; globulin, 2.0. June 13, 1944, plasma proteins, 4.8; albumin, 2.5; globulin, 2.55. Blood counts were as follows: May 29, 1944; red blood cells, 5,600,000; hemoglobin, 16.4; white blood cells, 9,625; polymorphonuclears, 66 (bands, 8, segmental, 58); lymphocytes, 32; monocytes, 1; eosinophiles, 1. June 8, 1944, red blood cells, 5,200,000; hemoglobin, 15.8; white blood cells, 8,500 polymorphonuclears, 67 (bands, 5, segmental, 62); lymphocytes, 32; monocytes, 0; eosinophiles, 1.

The patient was operated upon June 2, 1944, under gas-oxygen-ether anesthesia.

Preoperative Diagnosis.—Diagnosis was abdominal tumor, probably hematoma.

Operation.—A left hemihepatectomy was performed.

Findings.—The tumor palpable in the upper abdomen proved to be the enormously enlarged left lobe of the liver. Beneath the serosa, tumor tissue could be seen over the entire visible surface of the left lobe. The right lobe of the liver was somewhat smaller than normal and about one-half the size of the enlarged left lobe. It was essentially normal in appearance and no nodules could be palpated in its substance. The stomach was adherent to the enlarged liver along almost its entire greater curvature. There were also omental adhesions to the inferior surface of the liver. The spleen was not enlarged. The gall bladder was normal in appearance, except for some thiekening and fatty infiltration.

Technique.—A left transverse incision was made beginning in the midline, midway between the xiphoid and umbilicus, and extending well into the left flank. This was later enlarged by right-angle extension in the midline to the left of the xiphoid, and the fused cartilages of the sixth and seventh ribs were sectioned. This incision allowed quite satisfactory exposure of the upper surface of the enlarged left lobe. The suspensory ligaments of the lobe were sectioned between clamps and ligated. In preparation for cutting across the isthmus between the right lobe and the left lobe, which was about six inches wide, an enterostomy clamp with rubber-covered blades was applied to the right of the contemplated incision for temporary control of the blood supply. Interlocking deep mattress sutures of No. 2 chromic catgut were inserted through the full thickness of the pedicle, entering and emerging on the superior surface, but not tied. With the ends of these sutures held snugly, a wedge-shaped incision was made through the pedicle, separating the left and right lobes of the liver. The mattress sutures were then tied and reinforcing sutures were placed over the cut surface of the liver from anterior to posterior edge. These were tied snugly and the enterostomy clamp was removed. Removal of the clamp was followed by bleeding from several vessels, which was promptly controlled by clamping and insertion of additional figure-of-eight sutures. Very little blood was lost from the liver incision. The adhesions between the left lobe and the stomach were then sectioned and bleeding points ligated on the stomach side. Adhesions

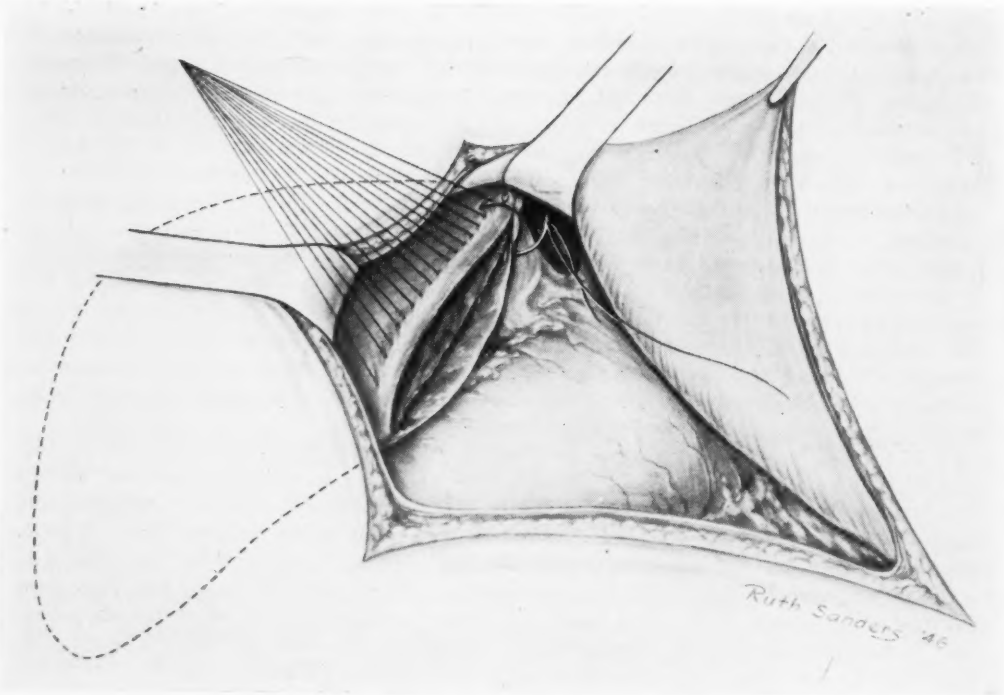

Fig. 1 (Case 1).—Resection of left lobe of the liver; mattress sutures are placed but not tied until the pedicle is cut through and the edges of the defect are approximated.

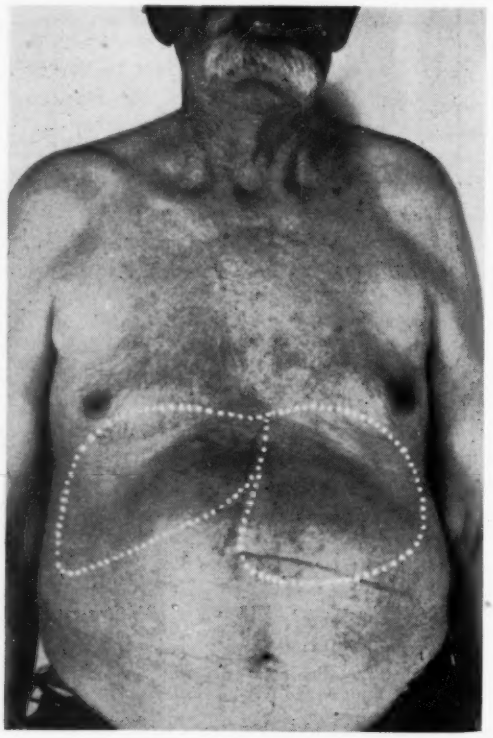

Fig. 2 (Case 1).—Photograph of patient showing healed L-shaped scar; dotted lines outline liver with tumor.

to the omentum were likewise sectioned and ligated. This allowed removal of the left lobe from the abdominal cavity. The wound was closed with continuous catgut sutures in the peritoneum, interrupted figure-of-eight steel alloy sutures in the fascial layers and rectus sheath. The skin was closed with continuous vertical mattress sutures of cotton. No drains were used.

Postoperative Course.—Following operation, the patient's condition was good. Temperature reached 101° F. But returned to normal on the third postoperative day and remained so until the sixth postoperative day, at which time the temperature rose to 100.2° F. At this time the patient began to complain of aching pain and tenderness in the calves of both legs, and showed signs of mild thrombophlebitis. The temperature reached 100 to 100.4° F. from the sixth to the sixteenth postoperative days. The thrombophlebitis gradually subsided without further complications. On the eighth postoperative day, the patient was allowed to be up in a wheel chair and was discharged in good condition on the twenty-third postoperative day. Elastic stockings relieved the pain in the legs, which were only slightly swollen. His

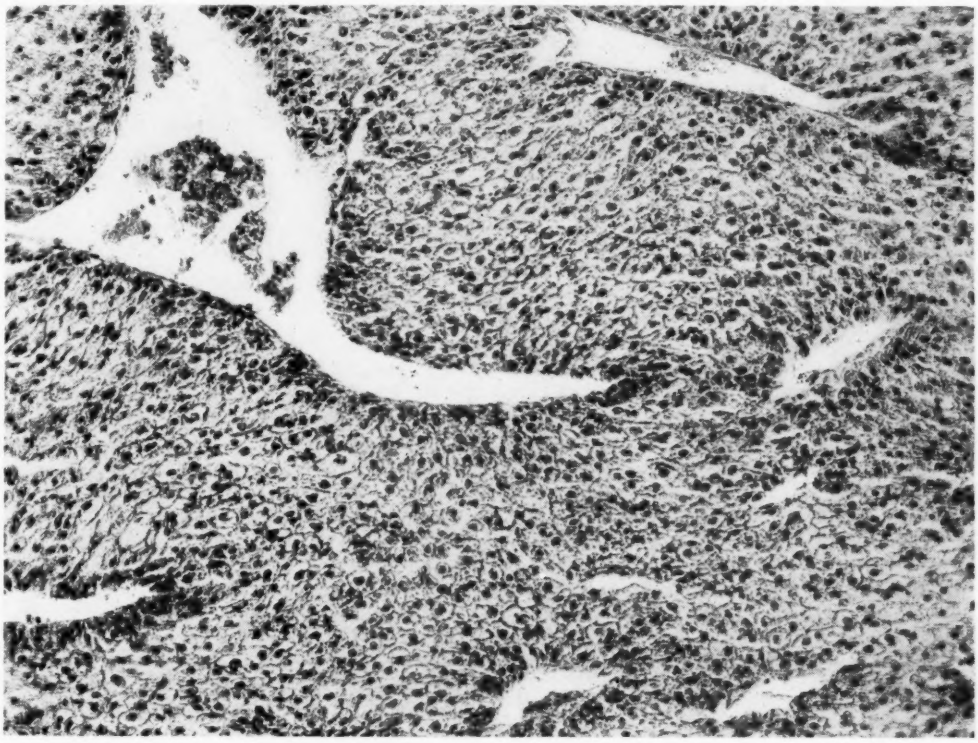

Fig. 3 (Case 1).—Photomicrograph of hepatoma.

course since discharge from the hospital has been quite satisfactory. No ascites has developed although the legs still swell moderately after he has been up for a few hours. His chief complaint now is that he is not allowed to ride horseback, or to help in the fields. Except for a slight bulge in the linea alba at the angle of the incision, the wound is firmly healed. He was last examined on March 15, 1946.

Pathologic Report.—A pathologic report was made on the liver, June 2, 1944. The specimen consisted of a large liver mass measuring 17 by 18 by 8.5 cm. It was covered by a thin smooth capsule on one side. The omentum was attached to the outer surface of the liver. The greater part of the mass was yellowish in color and contained blood vessels which could be seen. There was a small portion of the mass measuring 10 by 5 by 3 cm. which looked like fairly normal liver. On section, the mass was composed of soft fragile grayish-yellow tumor tissue in which were multiple hemorrhagic areas. There were several small

cystic areas filled with light yellow mucoid material. The tissue in many places was so soft that it appeared necrotic. There were many white strands which divided the tumor tissue into large lobules. The tumor tissue stopped abruptly where the normal liver tissue began. The cut surface where the liver was removed measured 10.5 cm. in length by 6 cm. This area also was composed of tumor tissue. Surface of the mass was not umbilicated.

Examination of sections of liver showed areas of relatively normal liver tissue on one side with distinct tumor tissue on the other and a grading of fibrous connective tissue partially embedded by tumor cells in between. The relatively normal tumor tissue was markedly hyperemic. The liver cords showed moderate swelling and there was even some variation in the chromatin content of the nuclei of the cells. The bile capillaries and ducts were not distended and they were lined by simple columnar epithelium which was regular. There was no increase in the fibrous connective tissue to any great extent in the periportal areas or within the central portions of the lobules which would denote cirrhosis. The fibrous connective tissue in between the relatively normal and tumor masses appeared to be an attempt on the part of the tumor to form a capsule. There was a sharp or fairly sharp delineation between the fibrous connective tissue along one side of it. The tumor tissue was composed of cords of cells which had a rather clear appearance, in that they were composed of rather large amounts of clear-staining cytoplasm with relatively small round or oval, at times somewhat granular, basophilic nuclei, which varied only slightly in size, shape, and chromatin content. The cords were fairly regular. Numerous small blood vessels were seen accompanying the tumor formation. The definite differentiation by secretion of bile was not definitely encountered. Moderate numbers of mitotic figures were seen.

Diagnosis.—The diagnosis was massive hepatoma, relatively benign.

CASE 2.—R. McM., a white male, aged 3 years, was admitted to Texas Children's Hospital, March 12, 1945, with complaints of mass in the upper abdomen for five weeks, vomiting of breakfast two or three times a week, for twelve days, increasing irritability for three or four weeks.

Present Illness.—On Feb. 19, 1945, the child was taken to the family physician in Duncan, Okla., because he was becoming "pot bellied." The large mass was found and the patient sent to Texas Children's Hospital in Dallas. He had been vomiting after breakfast every two or three days for the past twelve days, had become increasingly irritable and paler, and in the preceding few weeks had complained of pain in the epigastrium. He had gained weight. There was no diarrhea and no tarry stools. The stools were brown and soft, usually one a day. Family history and past history were essentially negative.

Physical Examination.—The patient was a well-nourished, well-developed, pale, white male child, lying quietly in bed, not acutely ill. The head and neck were not abnormal. Eyes, ears, nose, and throat were not abnormal except for pale mucous membranes. The chest expansion was equal; breath sounds were satisfactory; the point of maximal impulse was the fifth interspace, just outside the left midclavicular line. In the heart there were no murmurs or arrhythmia; the rate at the apex was 90, blood pressure 90/70. The abdomen was distended, and there was a round, smooth, nontender, hard mass occupying the upper right three-fourths of the abdomen that moved with respiration. This mass appeared to be attached to or part of the liver. The liver could not be outlined as such. The kidneys and spleen were not palpable. In the rectum no masses were palpated. Glandular system contained no lymphadenopathy. The genitals were normal, as were the extremities. The skin was pale, but otherwise not abnormal. Reflexes were physiologic and equal.

Laboratory Studies.—Blood count on March 13, 1945, revealed red blood cells, 4,020,000; hemoglobin, 8.7; white blood cells, 11,200; polymorphonuclears, 67 (bands, 1, segmental, 66); lymphocytes, 30; monocytes, 3. Urinalysis reaction was acid; albumin; red blood cells were rare; sugar was negative; casts were negative.

Laboratory tests made by the family physician before admission to hospital were as follows: Feb. 19, 1945, red blood cells, 4,820,000; white blood cells, 18,000; hemoglobin, 68 per cent; 11.5 Gm.; stab cells, 2 per cent; segmented, 44 per cent; lymphocytes, 50 per cent; monocytes, 2 per cent; eosinophiles, 1 per cent; myelocytes, 1 per cent; marked achromia,

moderate poikilocytosis. Sedimentation rate was 20 mm.; fragility test 0.4 to 0.28; icterus index 6.4; packed cells 40 per cent; volume index 44; color index 68; saturation index 1.6. On Feb. 23, 1945, the urine was negative and there was no bile. Feces showed no fat droplets. There were the usual vegetable cells and fibers and starch granules. Muscle fibers were rare; no ova or parasites. Occult blood was found; benzedrine test was two plus. There was no guaiac; bile was negative. March 5, 1945, red blood cells were 4,120,000; hemoglobin, 56 per cent; sedimentation rate was 50 mm.

Operative Record

First Operation.—March 15, 1945, exploration and biopsy of liver tumor were carried out.

Findings.—A left upper rectus muscle-splitting incision was made. Upon opening the abdomen, the large, palpable mass proved to be a tumor of the liver, which occupied almost

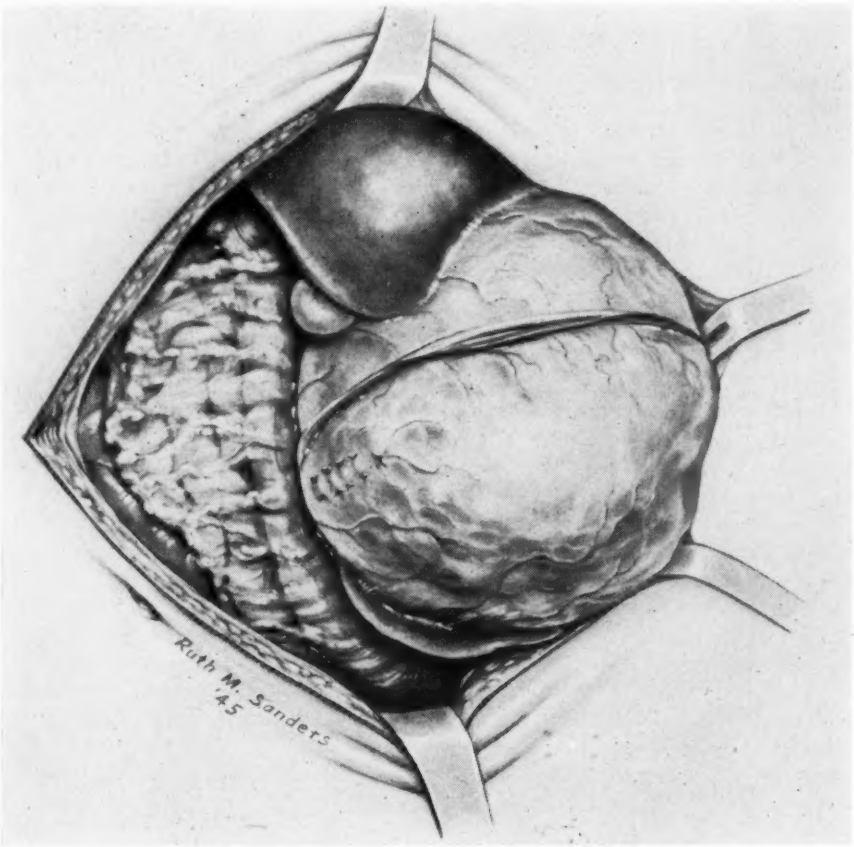

Fig. 4 (Case 2).—Massive hepatoma replacing most of left lobe and invading right lobe; sutures show site of biopsy.

the entire upper half of the abdominal cavity. This tumor was spheroidal in shape. It had replaced almost the entire left lobe of the liver and a large part of the right lobe. There was a narrow fringe of liver tissue about 2 cm. wide, attached to the tumor along its left margin, and a thin layer of liver tissue representing the remaining portion of the left lobe could be palpated behind the tumor. The tumor compressed the right lobe against the right abdominal wall and invaded its substance deeply. The presenting surface of the tumor was a mottled, grayish red in color and was covered by a fairly thick capsule which contained

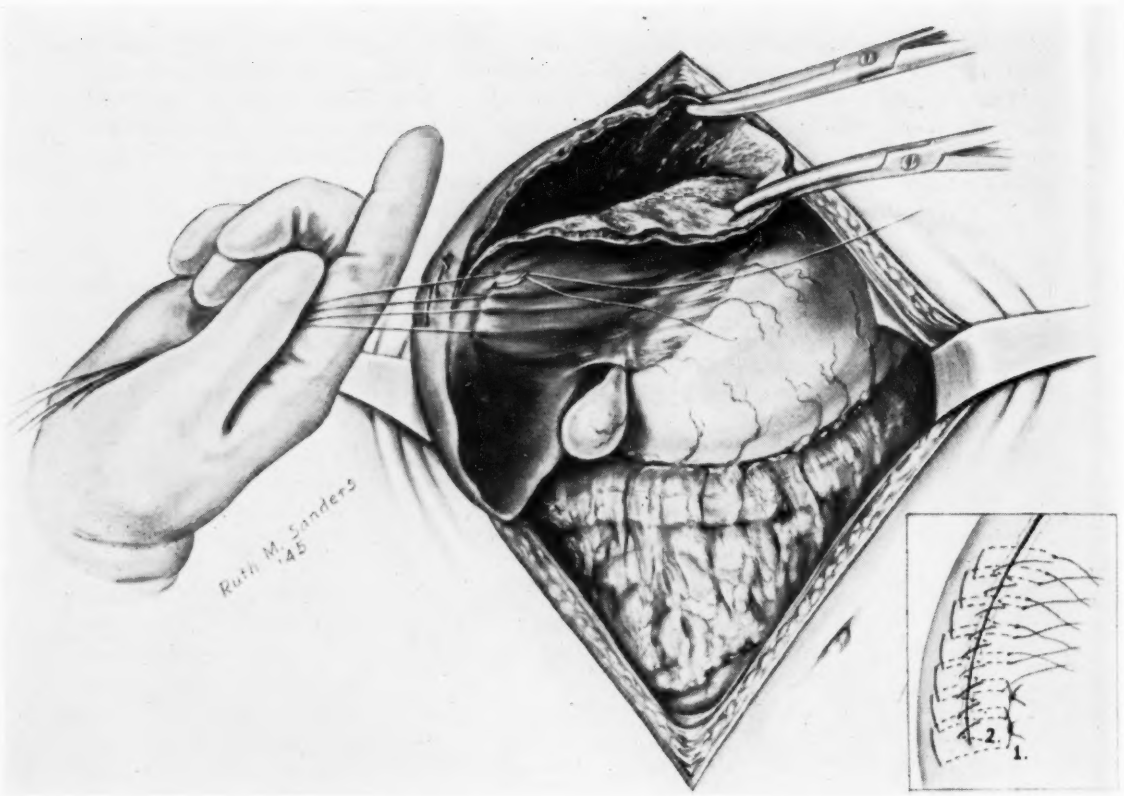

Fig. 5 (Case 2).—After tumor has been enucleated margins of left and right lobe remnants are approximated with interlocking mattress sutures and a continuous suture.

Fig. 6 (Case 2).—Tumor after removal.

numerous anastomosing venous channels. The remnant of the right lobe contained a small, raised, grayish area on the anterosuperior surface which was separated from the margin of the tumor. Upon section, this area had the appearance of essentially normal liver tissue. The gall bladder was normal in size and color, but was displaced somewhat toward the right, together with the bile ducts. There was a very thin layer of liver tissue between the tumor and the portal fissure. The stomach was displaced downward and to the left, but was essentially normal in appearance. The spleen was normal.

What Was Done.—After thorough examination of the liver and the tumor, resection of the tumor seemed impractical. A biopsy was taken from the anterior surface of the tumor mass, and bleeding was controlled by a series of interlocking mattress sutures of cotton which were placed before the specimen was removed to allow insertion of a series of interrupted sutures, approximating the edges of the defect. The wound was closed in layers without drains, using continuous catgut in the peritoneum, interrupted figure-of-eight cotton sutures in the anterior rectus sheath, and continuous vertical mattress suture of cotton in the skin.

Pathologic Report.—

Gross examination: The specimen consisted of a small bit of tissue measuring 1 by 0.5 by 0.2 cm. The surface was covered with a thick capsule, and beneath this the tissue was firm and yellowish brown in color, resembling fatty liver tissue.

Microscopic examination: The section stained with hematoxylin and eosin revealed tumor tissue bordered on one side by a thick fibrous capsule. Beneath the capsule there was an area containing numerous bile ducts and foci of hepatic parenchymal cells. This area was separated from the main body of the tumor by a thin fibrous band. The main body of the tumor was composed of cords of large cells resembling liver parenchyma cells which were growing in orderly fashion, but not in well-developed lobules. These cells showed marked fatty metamorphosis. In a few areas small bile thrombi could be seen beneath these cells.

Pathologic diagnosis: The diagnosis was benign hepatoma. Recovery from this operation was uneventful. A diagnosis of encapsulated hepatoma was made from the biopsy specimen, and an attempt to resect it was decided upon.

Second Operation.—On March 26, 1945, resection of the hepatoma was carried out.

Findings.—The findings were as described at the previous exploratory operation, March 15, 1945, there were no adhesions to the wound where the biopsy was taken.

What Was Done.—A long, right rectus, muscle-splitting incision was made, paralleling the healing incision to the left. At the upper end, the new incision was extended by section of the costochondral cartilage up to the margin of the sternum. The falsiform and coronary ligaments of the liver were sectioned and ligated with cotton. Several large blood vessels, both arteries and veins entering the tumor on its superior surface, were clamped, sectioned, and ligated. Beginning at the anterosuperior margin of the tumor where it invaded the substance of the right lobe, a line of cleavage was established by incising the outer layers of the capsule of the tumor. This line of cleavage was developed laterally and downward toward the anterior margin of the liver, and paired clamps were placed in succession along the margin of the liver tissue about 2 cm. from the tumor. The liver tissue and the outer layer of the split tumor capsule were sectioned together between the clamps which included most of the blood vessels entering the tumor. This procedure was continued around the entire circumference of the tumor, passing from the right lobe to the left lobe in the portal fissure. The tumor mass, together with the attached portions of the liver margins, was then quickly enucleated and the resulting cavity filled with a large, moist pack. Hemorrhage was quite successfully controlled by this procedure. After compression for about five minutes, the pack was gradually withdrawn and the thin shell of liver tissue representing the posterior remnant of the left lobe was tightly compressed against the remaining right lobe. The cut margins of liver which were still retained in the hemostatic forceps originally applied were then sutured together by interlocking, deep, mattress sutures of No. 0 chromic catgut. These sutures entered the liver substance about 2 cm. back from the cut edges. The clamps were then removed and a few bleeding points secured with additional mattress sutures. The edges of the defect were then more closely approximated with a continuous suture of No. 0 chromic catgut. It

was estimated that about one-third of the substance of the normal liver remained. Liquid and clotted blood was removed from the abdominal cavity and the wound was closed in layers without drains as at the previous operation. During the operation, 400 c.c. citrated blood and 17.5 Gm. concentrated plasma were administered by vein. The immediate postoperative condition was excellent.

Laboratory Findings After Operation.—March 27, 1945, hemoglobin was 10 Gm.; red blood cells, 3,590,000; white blood cells, 35,600; polymorphonuclear, 71 per cent (bands, 22, segmental, 49); urea nitrogen, 16.2; blood sugar, 85.5. On March 30, 1945, hemoglobin was 5.9 Gm.; red blood cells, 2,810,000; white blood cells, 32,450; polymorphonuclears, 68 per cent (bands, 6, segmental, 62). April 9, 1945, hemoglobin was 13.9 Gm.; red blood cells, 4,150,000; white blood cells, 20,600; polymorphonuclears, 65 per cent (bands, 2, segmental, 63). April 10, 1945, lymphocytes, 30 per cent; monocytes, 4 per cent; eosinophiles, 1 per cent. Wassermann reaction was negative, Mantoux was negative, and Rh positive. April 12, 1945, hemoglobin was 15.5 Gm.; red blood cells, 4,240,000; white blood cells, 17,100; polymorphonuclears, 66 per cent (bands, 7, segmental, 59), lymphocytes, 28 per cent; monocytes, 6 per cent.

Postoperative Course.—Wangensteen suction was started and nothing given by mouth for twenty-four hours, when water was given and retained. Very little distention developed, and the suction was discontinued, after forty-eight hours. Glucose solution and citrated blood were given by vein. Temperature ranged from 100 to 102° F. There were no signs of shock. On the fourth postoperative day, a small mass thought to be the liver was palpated below the right costal margin. The blood count fell to 2,810,000 red blood cells and continuing hemorrhage in the bed of the tumor was suspected. Although the blood count increased after several transfusions, this mass did not recede and was present when the patient was discharged from the hospital on April 15, 1945. The wound was strongly healed. After returning to his home in Oklahoma, the child failed to continue improving. The mass in the liver region steadily increased in size until it was the size of the original tumor. He died on June 22, 1945. No autopsy was obtained, but it is probable that recurrence of the hepatoma was responsible for his death.

CASE 3.—N. E. H., a white male, aged 20 months, was admitted to Bradford Hospital, Oct. 19, 1945, with the complaint of a mass in the right side just under the ribs, for four months.

Family History.—The mother and father were living and well. There was one sibling 6½ years of age and two adopted children. There were no familiar diseases.

Past History.—Birth was full term by cesarean section, Feb. 4, 1944; the mother's pelvis was inadequate, she had had prenatal care. Birth weight was 7 pounds, 15 ounces. Development was normal. The child had had eight attacks of otitis media, with frequent accompanying sore throat. Both eardrums had been lanced December 26, 1944.

Present Illness.—The mother first noticed that the child did not take solid foods well. She accidentally discovered a mass on the right side beneath the ribs in June, 1945, and he was first treated in the city where he lives. Roentgenogram of the chest was clear, and pyelograms were done, but nothing showed conclusively. Inasmuch as the impression was that of a tumor of the kidney, twelve deep x-ray treatments were given, after which the child became quite ill. Surgery was done on Aug. 6, 1945, and a tumor of the liver found. Biopsy was taken and microscopic diagnosis of benign hepatoma was made. Recovery from surgery was complicated by paralytic ileus, which was relieved by prostigmine and Wangensteen suction. The child had crystalluria at that time. Resection of the tumor was advised and the patient was admitted to Bradford Memorial Hospital, Dallas, for operation.

Physical Examination.—Temperature was 99.4° F., weight 25 pounds, 7 ounces. The patient was a well-developed, well-nourished, 20-month-old white male, who was very fretful but in no acute distress. Examination of the head, eyes, nose, and neck was negative. In the ears the right tympanic membrane was slightly injected around the margin. Findings in the throat were negative except for markedly enlarged tonsils, which were slightly injected. Lungs were clear to the posterior and anterior; there were no râles. The heart was normal.

There was marked distention in the abdomen and the liver was three fingerbreadths below the costal margin. The spleen was not felt; there was no fluid wave. The venous pattern was definite with blood flowing away from the umbilicus.

Laboratory Studies.—Urinalysis, Oct. 14, 1945, was negative. On Oct. 20, 1945, it was negative except for occasional white blood cells. Blood count Oct. 14, 1945, was hemoglobin, 10.10 Gm.; red blood cells, 4,470,000; white blood cells, 9,200; polymorphonuclears, 51 per cent (bands, 9, segmental, 34, y.8); lymphocytes, 36 per cent; monocytes, 9 per cent; eosinophiles, 4 per cent. On Oct. 16, 1945, hemoglobin was 12.9 Gm., red blood cells, 4,940,000; white blood cells, 13,850; polymorphonuclears, 74 per cent (bands, 10, segmental, 60); lymphocytes, 25 per cent; monocytes 1 per cent.

Operation.—Oct. 14, 1945, resection of the anterior margin of the right lobe of the liver containing the tumor was done.

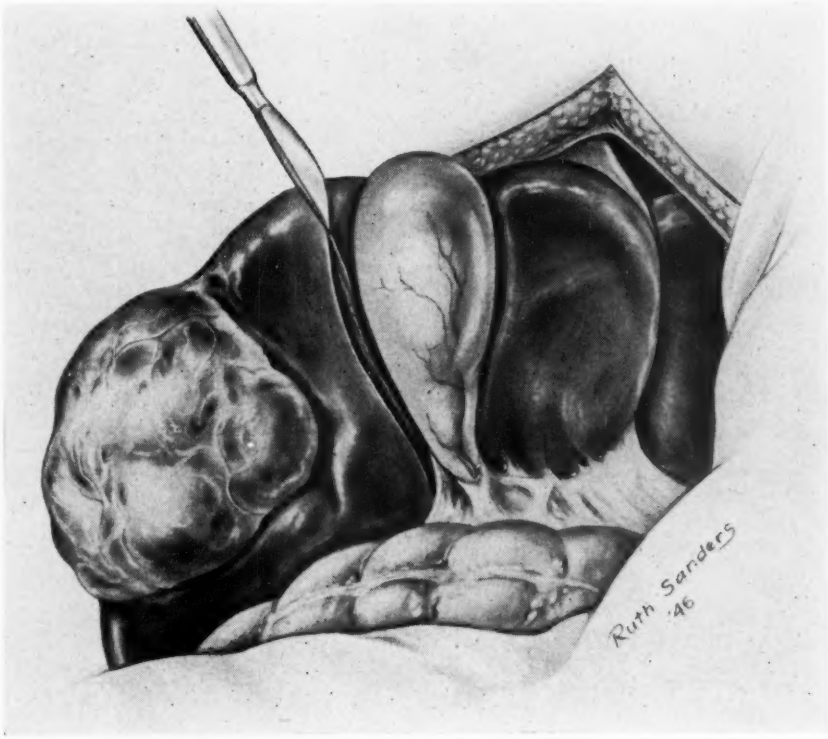

Fig. 7 (Case 3).—Undersurface of liver showing tumor and incision being made in capsule of liver for mobilization of the gall bladder.

Findings.—There was a healed scar of a long right upper rectus incision. Upon opening the abdomen, the palpable mass was found to be a tumor embedded in the anterior margin of the right lobe of the liver. The tumor was about 6 cm. in length and 4 to 5 cm. in thickness. Approximately one-half its area protruded beyond the line of the liver margin. The tumor was irregular in outline and mottled grayish red in color. Its margin was fairly well defined. The left lateral margin of the tumor was located about 3 cm. from the gall bladder fossa. The gall bladder was normal in size and appearance. The liver was possibly a little enlarged but was otherwise normal in appearance. No other tumor masses could be seen or felt. On the anterior surface of the tumor was a small scar, representing the site of a biopsy previously removed elsewhere. To this scar, a loop of small intestine was densely adherent. The stomach, duodenum, and the remaining portions of the intestinal tract were normal.

What Was Done.—The scar of the previous operation was excised and lengthened to extend from the costal margin to a point 3 cm. below the umbilicus. The rectus muscle was split and the fibers separated at about its mid-point, and the peritoneum was incised. The adherent loop of small intestine was separated from the surface of the tumor and the raw area on the wall of the intestine was inverted with a purse-string (fine catgut) suture. In preparation for resection of the tumor mass, the gall bladder was mobilized almost to its base and was displaced to the left, exposing almost the entire gall bladder fossa. A series of interlocking mattress sutures of No. 0 chromic catgut were placed in a curved line through the substance of the liver outlining the tumor and a margin of liver tissue about 2.5 cm. wide. Each suture entered the superoir surface of the liver, penetrated the liver, emerged through

Fig. 8 (Case 3).—A row of interlocking mattress sutures placed and held while tumor is resected.

the inferior surface, and again traversed the liver to the superior suface. All mattress sutures were placed and held but not tied until the resection was done. The tumor mass, together with the adjacent margin of liver, was resected in one mass, using a wedge-shaped incision so that the margins of the liver could be approximated in a transverse direction. As the incision was made from the left to the right side, the previously placed mattress sutures were drawn tight and tied. Into the troughlike defect remaining on the margin of the liver, masses of fibrin foam, soaked in thrombin solution, were placed. A series of simple sutures were placed across the margins of the incision in the liver and tied over the masses of fibrin foam. These sutures resulted in a fairly accurate approximation of the liver edges, satisfactorily closing the defect. Very little hemorrhage was encountered and no attempt was made

to identify and ligate individual bleeding points. After all sutures were tied, bleeding was completely controlled. The free edge of the omentum was turned upward and secured along the margin of the liver by ligation with the long ends of the second row of catgut sutures, crossing the liver margins. The wound was closed in layers without drains, using fine chromic catgut continuous suture in the peritoneum, interrupted No. 50 cotton sutures in the anterior rectus sheath, and interrupted cotton in the skin.

Pathologic Report.—

Source: The tumor was from the lower border of the right lobe of the liver.

Gross examinations: The specimen consisted of a lobular tumor mass, measuring 6 by 3½ by 1 cm., together with a surrounding portion of apparently normal liver. The mass

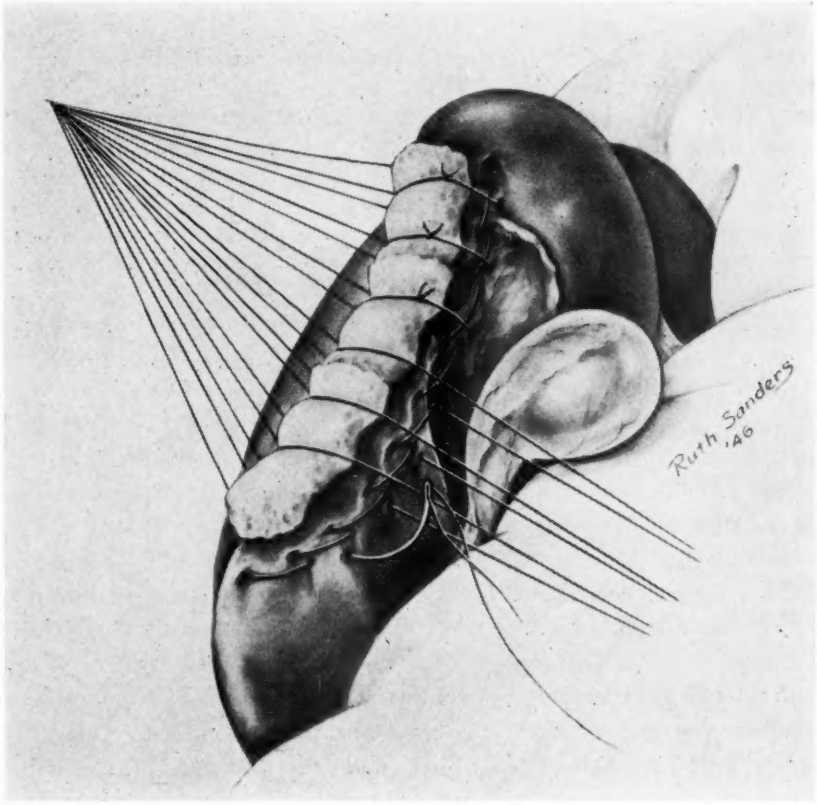

Fig. 9 (Case 3).—Fibrin foam placed in defect and held by second line of interrupted sutures; mattress sutures are tied last.

projected from the liver edge and was covered by what appeared to be a normal extension of the capsule of the liver. It was a smooth, rounded mass with very slight nodulation. There was a mottled, red and light yellow appearance to the surface. There was one area of hemorrhage into the connecting tissues at one extremity of this mass. On cut section there were seen rounded areas 5 to 8 mm. in diameter, separated by apparently fibrous tissue trabeculae. Nodules varied in color from a homogenous light grey to other nodules which were brownish in appearance. There was no definite gross extension into the apparently normal parenchyma which was attached and surrounded the tumor and there was a suggested, but not definite capsule. The mass was firm throughout and there was no suggestion of necrosis.

Microscopic examination: Staining the section with hemotoxylin and eosins revealed, in the tumor mass, cords and sheets of cells separated by fibrous tissue strands which contained moderate numbers of infiltrated small, round, mononuclear cells. The tumor cells had a strong resemblance to normal liver cells, but they were irregular and stained more deeply than the normal liver parenchyma cells. There were occasional multinuclear cells but characteristic large tumor giant cells were not found, nor were mitoses seen in any great frequency. At the border of the tumor small nests of tumor cells were seen and there was no definite demarcation from the surrounding normal liver parenchyma. The latter did not show any increase in fibrous tissue at the pontil triads. The fibrous tissue septa of the tumor itself were extremely vascular, exhibiting many dilated capillaries. In numerous locations masses of tumor cells surrounded blood-filled sinuses, from which they were separated only by a thin and sometimes incomplete endothelial lining. In several locations there was seen a tendency for tumor cells in small nests or protuberance of tumor cells to occur in the lumina of these sinuses.

Pathologic Diagnosis.—The pathologic diagnosis was primary liver cell adenoma, hepatoma in type, with malignant tendencies.

Postoperative Diagnosis.—Postoperative diagnosis was hepatoma, relatively benign.

Course in Hospital.—The tumor mass was resected on the third hospital day. Temperature rose to 104° F., and gradually fell to 101° F. by the sixth hospital day. Temperature became normal on the fourteenth hospital day and the patient was discharged on the sixteenth hospital day. Wangensteen suction was started and discontinued on the second postoperative day. Recovery over a period of two weeks was uneventful. Treatment was symptomatic and supportive.

On April 1, 1946, he was reported to be in perfect health and gaining weight steadily.

COMMENT

Our cases represent the age groups at the extremes of life where extensive radical surgery is ordinarily most dangerous. Carefully chosen and skillfully administred anesthesia is, in a large measure, responsible for the successful outcome of the surgical procedure in each case. Of equal importance was the prevention of excessive blood loss. Whole blood was being administered by vein during the course of each operation as a precautionary measure, but relatively little hemorrhage occurred. The plan of placing the line of interlocking mattress sutures before the incision in the liver was made, and exerting traction on all of the untied ends as the incision was made succeeded in compressing the larger vessels whose open ends emerged on the cut surface. Only capillary hemorrhage was, therefore, encountered and this was soon controlled by the approximation of the cut surfaces with the second line of sutures passing over the edges. The use of the enterostomy clamp for compression of the pedicle in the first case was of questionable value.

In the third case, an additional aid was used for control of the capillary bleeding. This was the fibrin foam* soaked in thrombin solution, applied to the cut surfaces and sutured into the liver wound. Thrombin topical was developed by Tidrick, Seegers, and Warner[15] in 1943, and used as a spray by them to control surface bleeding in skin graft donor sites, bone surfaces, gall bladder beds, mastectomy wounds, etc.

*The fibrin foam and thrombin used by us was obtained from the Office of Scientific Research and Development, Harvard University, where it is available for clinical experimental use.

Another newly devised substance which would probably serve a similar purpose is absorbable gauze or cotton (oxidized cellulose).*

The most recently developed hemostatic agent is absorbable gelatin sponge.† A water-soluble gelatin base sponge has been obtained by foaming a specially prepared gelatin solution, which is then air dried in metal forms, and subsequently sterilized for biologic use. The dried product is a light, off-white, nonelastic, tough, porous mold that may be cut into any shape or size. It has no tendency to fragment while being handled. This sponge is not antigenetic. Tests prove it to be absorbed in twenty to thirty days. In use the sponge is dampened with a thrombin solution and the squeezed-out sponge is applied to the bleeding area, where it quickly absorbs blood, which clots upon coming into contact with thrombin.

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*Prepared in the Research Laboratories of the Eastman Kodak Company, Rochester, N. Y., and sterilized, by formaldehyde sterilization, by Parke, Davis & Company, Detroit, Mich.

†Prepared by The Upjohn Company, Kalamazoo, Mich.

A ONE-STAGE PHARYNGOESOPHAGEAL DIVERTICULECTOMY

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OUR purpose in writing this paper is to present an original method for doing a one-stage pharyngoesophageal diverticulectomy. This method has proved itself to be basically sound because it has been employed successfully for over ten years with great satisfaction to operator and patient.

The surgical treatment of pharyngoesophageal diverticulum has had a varied career. E. von Bergmann and Kocher were among the first to do successful one-stage diverticulectomies. They were outstanding men of their time and their success with this one-stage procedure encouraged many other contemporaries to attempt the same type of operation. Complications followed many of these attempts at one-stage diverticulectomies, and soon there was considerable doubt cast on the wisdom of doing the operation in this way. Leakage from the ligated stump was mentioned as the most common cause of failure. Leakage led to spreading cellulitis along the fascial planes of the neck, and at times it extended even into the mediastinum and involved the lungs, pericardium, and pleura. It was Goldmann who first performed a successful two-stage operation. Halsted, Mayo, Judd, and Lahey later added their individual modifications to the two-stage procedure. However, all these men emphasized the fact that they preferred the two-stage diverticulectomy because it afforded the greatest amount of protection to the mediastinum.

A two-stage operation does not always afford protection against cellulitis and mediastinitis. If leakage occurs it is more likely to come to the surface in the two-stage procedure because the adhesions and walling off of the immediate area about the diverticulum offer a barrier to the extension of infection into the depths of the neck or mediastinum. If one could be assured that the stump left after diverticulectomy would not leak, there would be rarely an occasion for the two-stage operation.

The fact that many of these patients are very poorly nourished makes it imperative that they receive careful preoperative preparation and the necessity for immediate postoperative support is obvious. Immediately preceding surgery a Levine tube is inserted into the stomach via the nasal route. If it is impossible to pass a suction tube due to the tip finding its way into the diverticulum, the tube can be directed easily into the stomach during the operation. We wish to assert ourselves strongly on the subject of when to begin postoperative feedings. It is our belief that patients fed too early (any time before the seventh day) are more likely to develop fistulous tracts. Disruption of the repaired pharyngoesophageal area may be caused if the patient is encouraged to swallow semisolid or solid food at an early date. Even

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liquids may cause undue stress on the loosely united wound edges. If consideration is given to parenteral feeding and to the use of the indwelling Levine tube, very few patients will suffer pressure disruption of the repaired defect and their general nourishment will be maintained or improved. Our patients receive their postoperative feedings via the Levine tube after intravenous fluids have been discontinued. They are fed in this manner until the eighth or tenth day after which time the Levine tube is removed and liquid feedings by mouth are instituted.

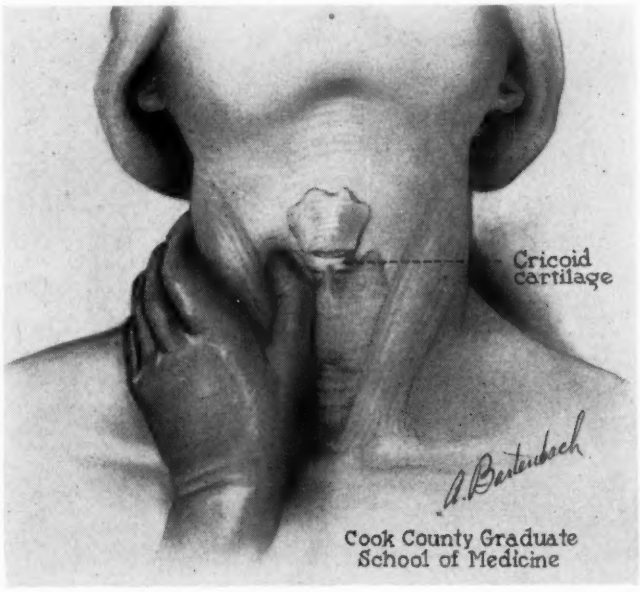

Fig. 1.—A method used to determine the position of the diverticulum.

The method we employ in one-stage pharyngoesophageal diverticulectomy will be described as it is done, namely, in steps and by the number:

1. The incision may be made on either side of the neck along the anterior border of the sternocleidomastoid muscle. It extends about one inch above the level of the cricoid cartilage to one and one-half inches below this level* (see Fig. 2).

2. The fascia along the anterior border of the muscle is divided and the muscle retracted laterally exposing the carotid sheath.

3. The lateral border of the thyroid gland is exposed and its margin clearly defined.

4. The carotid sheath, its vessels, and nerve are retracted laterally by a ribbon retractor. The thyroid gland and its underlying larynx and trachea are retracted medialward.

*A simple method for determining the side of the neck on which the diverticulum lies and thereby establishing the probable site for an incision has been described by one of us (R. W. McN). It is performed as follows: The patient facing the examiner (sitting or standing) is asked to swallow air several times in succession. The examiner's right thumb gently but firmly compresses a point on the left side of the patient's neck anterior to the sternocleidomastoid muscle at a level even with the cricoid cartilage. If the diverticulum happens to be on the left side, the swallowed air in it will be forced out by the pressure of the examiner's thumb and create a loud gurgling sound. Both sides of the neck are tested in this manner.

5. The loose areolar tissue between thyroid and the carotid sheath supports the inferior thyroid artery which usually should be ligated and divided.

6. If the lateral margin of the esophagus is now identified, the position of the diverticulum can be established by remembering that its neck is at the

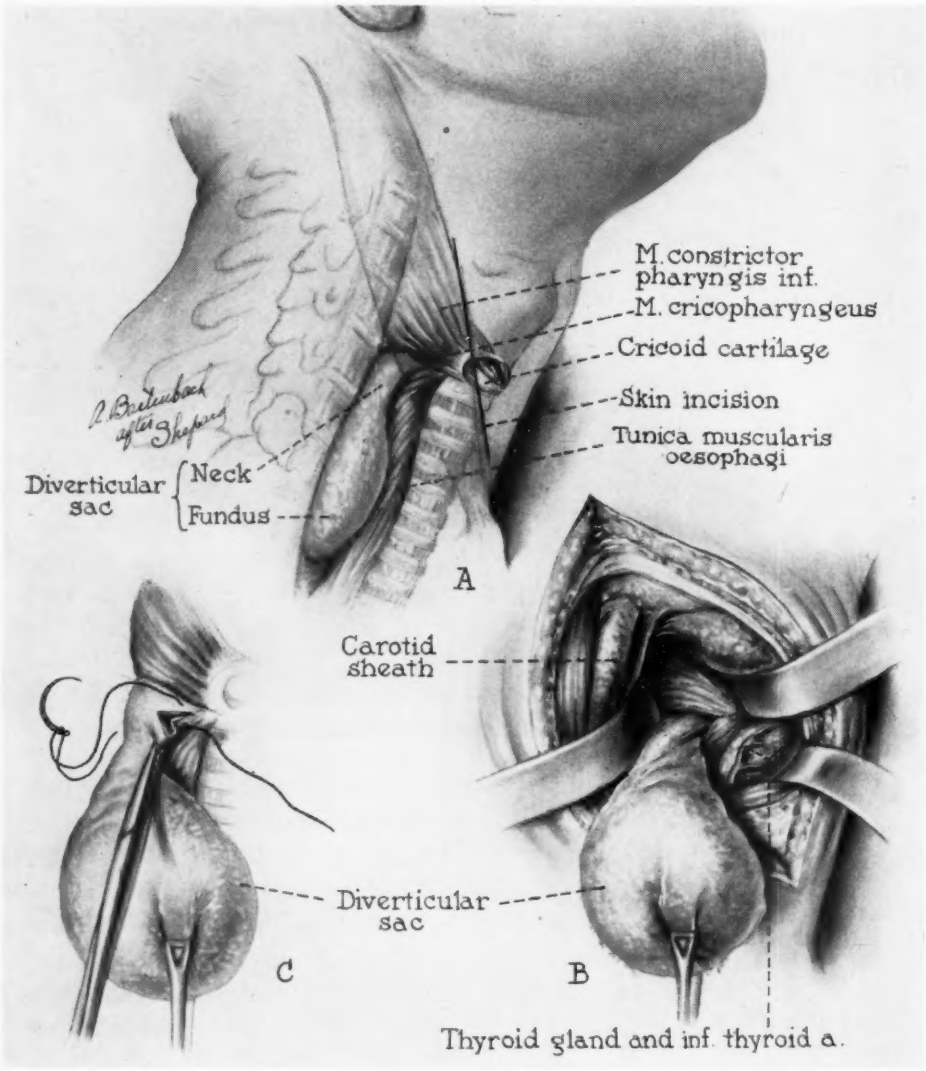

Fig. 2.—*A*, *B*, and *C*, position of sac and its relation to neighboring structures.

level of the cricoid cartilage and its fundus extends downward between the posterior wall of the esophagus and the anterior surface of the prevertebral fascia.

7. Careful traction on the wall of the diverticulum with a Babcock (or similar nontraumatizing forceps) will bring the sac into the more superficial regions of the incision where its size and conformation can be clearly studied.

8. The neck of the sac is now clearly exposed and by lifting gently it will be found that it is possible to rotate the pharyngoesophageal area into direct vision. The extent of the rotation of the esophagus and trachea around the longitudinal axis of these structures has been studied in the living and fresh post-mortem specimens. It is found that with moderate tension this rotation amounts to between 45 and 90 degrees. The maneuver will bring the neck of the sac into a completely visible and accessible position. The recurrent laryngeal nerves are not rendered more vulnerable by this rotation; on the contrary this maneuver permits a better view of the proximal nerve and the distal one is not drawn into the field of danger (Fig. 3).

9. The muscle fibers of the boundaries of the neck of the diverticulum are now clearly separated from the sac wall with maneuvers which will preserve as many of them as possible because they can be utilized subsequently to reinforce the suture line of the repaired defect (see Fig. 4).

10. It is important that the proximity of the recurrent laryngeal nerves be kept in mind (see Fig. 3).

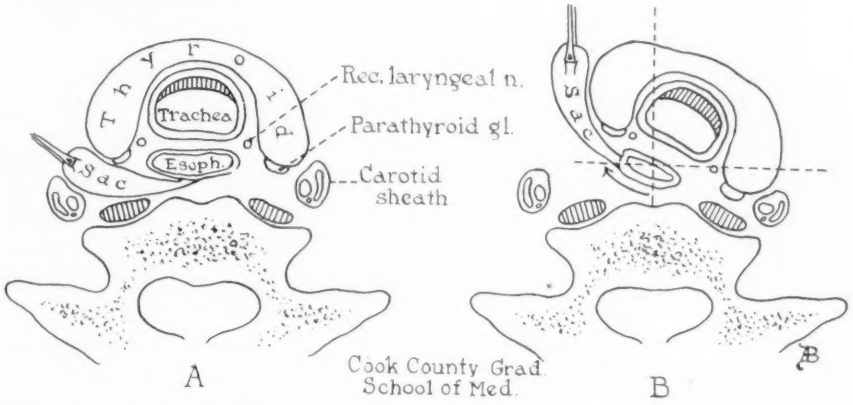

Fig. 3.—*A* and *B*, The mobility of esophagus and diverticulum is diagrammatically illustrated.

11. After a careful survey of the neck of the sac a point is selected at its lateral margin on a level with the cricoid cartilage and a fine forceps is applied transversely. A knife is used to divide the tissue proximal to the jaws of the forceps. This will make the initial opening into the esophagus. The opening is then sutured with one or more interrupted fine silk sutures. A second forceps is applied just beyond the first forceps, care being taken to continue at the same level and maintain the same transverse character of the division. As subsequent forceps are applied and the tissue divided proximally to them, the opening in the esophagus is sutured by carefully spaced interrupted sutures until the entire diverticulum has been severed from the pharyngoesophageal junction. This rather methodical clamping, division, and suturing results in a secure closure of the defect in the esophagus without the danger of undue narrowing and constriction and without leaving crushed and devitalized tissue in the grasp of the sutures. The well-spaced interrupted sutures bring the mucosa into intimate apposition and secure the holding submucosal layer against separation by their distribution of the tension evenly

across the posterior wall of the viscus. The diverticulum has been detached from its base in a transverse diameter so that the danger of postoperative stricture formation is greatly lessened (Fig. 4, *A*, and 2, *C*).

12. The muscle fibers of the cricopharyngeus and the uppermost fibers of the esophagus are then drawn over the first suture line with interrupted sutures as shown in Fig. 4, *B*, *C*, and *D*.

13. A small soft rubber drain may be inserted down to the lateral margin of the thyroid gland to provide a pathway along which blood or serum may escape. It will likewise form a pathway of easy exitus for any leakage, should it occur.

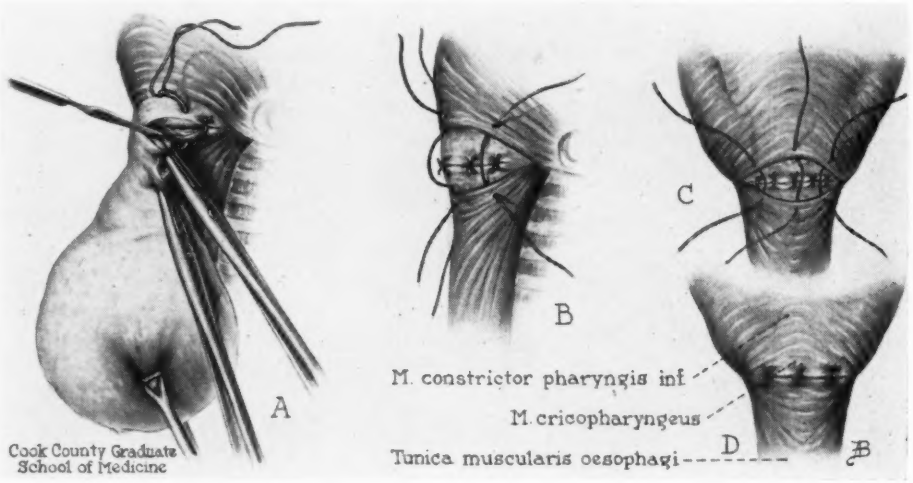

Fig. 4.—*A*, A method of transverse division of sac and application of interrupted sutures. *B*, *C*, and *D* illustrate the completed suturing of the transverse division of the neck of the diverticulum; reinforcing sutures through the muscle fibers of cricopharyngeus and muscle fibers of esophagus are also shown.

In no instance should the wick be carried down to the immediate vicinity of the suture line where it would inhibit the reparative processes by carrying away the plastic exudate from the suture line.

The following quotation is taken from an article on "Esophageal Diverticula" that appeared in a journal of surgery published during the past year. It seems to us that it is a glaring example of unorthodox surgical procedure.

"Two pairs of Shoemaker colectomy (1) *clamps* are then applied side by side near, but not too near, to the neck of the pouch. This pouch is now removed by cutting between clamps with the knife or diathermy needle, the line of section between the blades of the remaining clamp being then painted with a little (2) *pure carbolic acid*. (3) *A continuous inverting suture* of 2/0 chromic gut is then inserted on a small curved needle over the clamp. The clamp is slid off and the suture at once pulled tight, inverting the edges of the sac. The same suture is then brought back along the whole length as a (4) *secondary invaginating stitch* and tied to the original end. A few further points of interrupted catgut suture are super added by greater security and the wound closed, leaving (5) *a rubber dam drain down to the suture line* for three or four days."

1. If one wishes to repair or restore the continuity of any hollow viscus, it is not considered beneficial to crush the edges which are expected to unite with one another. We wish to emphasize the importance of suturing freshly divided, nontraumatized tissue in closure of defects of hollow viscera. Tissue that has been crushed lessens the likelihood of a favorable union because nonviable tissue will be included in the suture lines and will offer dead tissue as a site for bacterial growth and extending infection and necrosis. This can hardly help but jeopardize the security of the sewn defect and ultimately lead to fistulous formation with all its complications.

2. The use of cautery and escharotics on the edges of defects retards reparative processes even more than crushing of the edges.

3. Continuous sutures have many disadvantages in plastic repairs. A continuous suture strangulates tissues. If one stitch of a continuous chain cuts through it tends to weaken the remaining line. Continuous sutures have a tendency to narrow lumens and to limit the normal elasticity of the region.

4. A further fault would be found in using the same continuous suture as a second line to cover the first. This would have all the disadvantages already described.

5. The use of drains is to be condemned if they act as wicks *down to* the suture line. The presence of plastic exudate along a sutured line is the first stage in its repair. The removal of this reparative exudate via capillary wick would delay healing and encourage leakage and fistula formation.

CONCLUSION

In selected cases a one-stage operation can be done successfully by a technique which we have described. However, there are cases which offer certain obstacles to a one-stage procedure, and these probably can be better handled by a two-stage operation. The surgeon should be guided by his familiarity with the advantages of each type of operation and select the one which is best suited to the particular case in hand. This is obviously a better plan than to limit oneself to the invariable use of one or the other method.

SURGICAL MANAGEMENT OF CARCINOMA OF THE RIGHT PORTION OF THE COLON WITH SECONDARY INVOLVEMENT OF THE DUODENUM, INCLUDING DUODENOCOLIC FISTULA: DATA ON EIGHT CASES

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CARCINOMA of the right portion of the colon is a relatively common disease. Secondary involvement of the duodenum by carcinoma of the right portion of the colon is rare. A recent case of carcinoma of the hepatic flexure complicated by a duodenocolic fistula aroused our interest in this subject.

REPORT OF CASES OF DUODENOCOLIC FISTULA

CASE 1.—A 52-year-old white man entered the Mayo Clinic on Dec. 7, 1945, complaining of epigastric pain of ten months' duration. The pain occurred about one hour after meals and some relief was obtained by drinking milk. Three or four months before admission to the clinic the patient had begun to have low abdominal cramping pain, nausea, and vomiting. Three weeks before admission intractable diarrhea developed. The stools often contained particles of undigested food. The patient had lost 20 pounds (9.1 kilograms) during the three months preceding admission. Appendectomy had been performed in 1941.

Physical examination revealed a soft and tender mass about 6 cm. in diameter in the right midabdomen. The concentration of hemoglobin was 10.8 Gm. per 100 c.c. of blood. Erythrocytes numbered 4,690,000 and leucocytes 12,000 in each cubic millimeter of blood. Roentgenologic examination after injection of a barium enema revealed a carcinoma involving the hepatic flexure. Perforation had occurred and a large duodenocolic fistula was present (Fig. 1).

Sulfasuxidine was given for four days preoperatively. Surgical exploration was carried out by one of us (B. M. B.) on Dec. 18, 1945, through a midright rectus incision. There was an extensive lesion of the ascending limb of the hepatic flexure. The lesion had perforated into the duodenum at about the junction of the descending and transverse portions. Although the duodenal involvement was rather extensive, the lesion was still freely movable and there was no evidence of distant metastasis. The right portion of the colon was freed from its lateral peritoneal attachments and detached from the duodenum. The involved portion of the duodenal wall was resected widely. It was fortunate that the portion of the duodenum surrounding the ampulla of Vater was not involved in the malignant process. This made it possible to carry out an adequate resection of the duodenal wall without endangering the entrance of the bile duct and pancreatic duct. The resultant defect in the duodenal wall was closed transversely to the long axis of the duodenum. The terminal 12 to 15 inches (30 to 38 cm.) of ileum, together with the cecum, ascending colon, and approximately one-half of the transverse colon, were resected, and the cut ends of the bowel were inverted. Intestinal continuity was re-established as a side-to-side antiperistaltic ileocolostomy. Ten grams of sulfathiazole were left in the peritoneal cavity. Closure in layers was performed. The patient was given a transfusion of 500 c.c. of citrated blood during the operation.

Convalescence was uneventful and the patient was dismissed from the hospital on the twenty-second postoperative day. Roentgenograms taken five weeks after operation showed some changes in the duodenal contour (Fig. 2). The patient has remained well during the four months that have elapsed since the operation.

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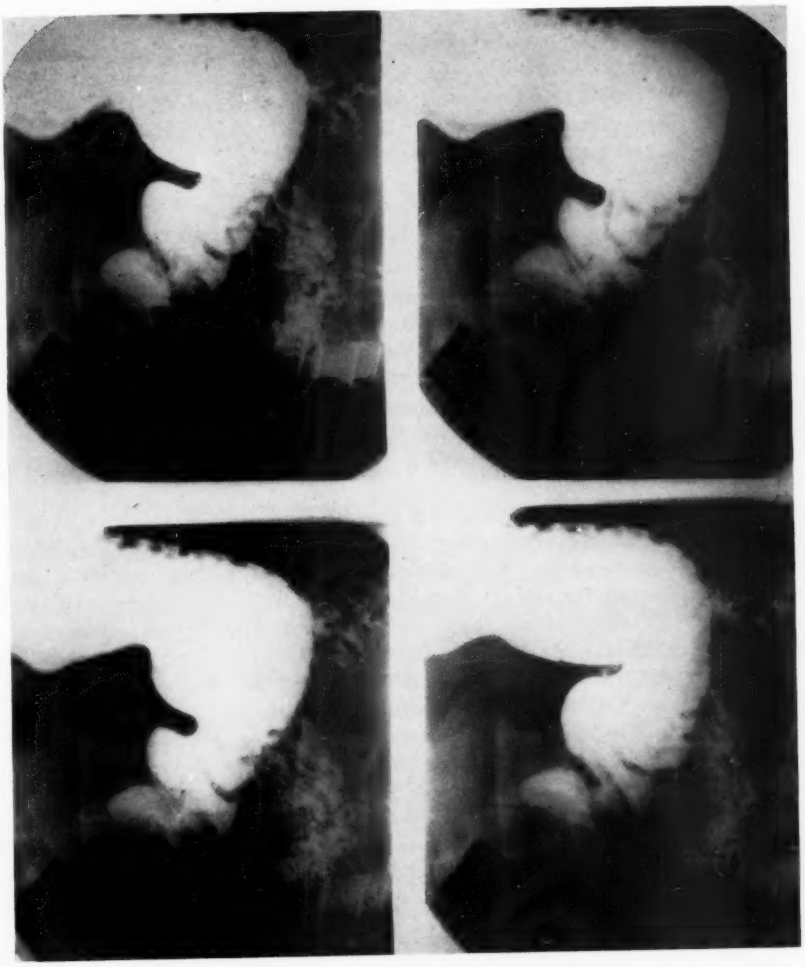

Fig. 2.

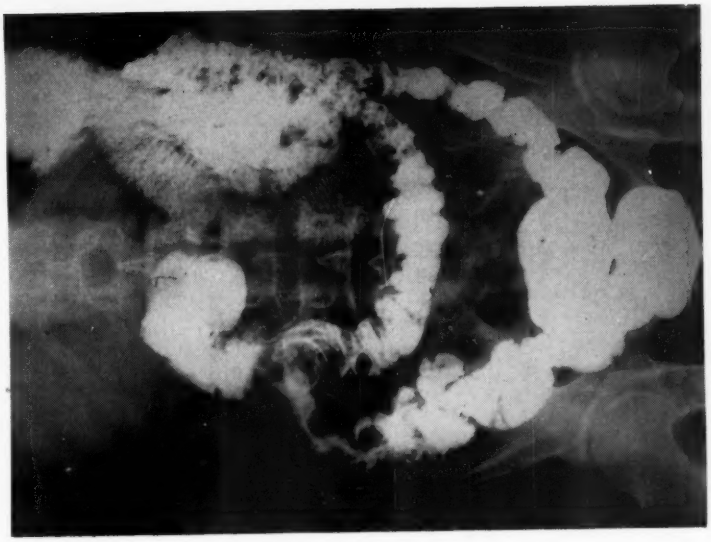

Fig. 1.

Fig. 1.—Carcinoma involving the hepatic flexure with perforation and development of a large duodenocolic fistula.
Fig. 2.—Roentgenograms of stomach and duodenum five weeks following operation, showing some postoperative changes in the duodenal contour.

On microscopic examination there was frank malignant involvement of the duodenum with adenocarcinoma, grade 3 (Broders' method). The primary lesion measured 7 by 6 by 4 cm. and was situated in the ascending colon near the hepatic flexure. Perforation into the duodenum had developed near the center of the growth. The peritoneum and several regional nodes were involved metastatically.

In one other case only, a duodenocolic fistula resulting from a perforating malignant lesion of the right portion of the colon has been treated at the Mayo Clinic.

CASE 2.—A 52-year-old white man entered the clinic on June 1, 1936, complaining of diarrhea, weakness, and vague abdominal discomfort of one month's duration. He had lost about 25 pounds (11.3 kilograms) during the past year. The physical examination gave essentially negative results. Roentgenologic examination of the stomach and duodenum showed a duodenocolic fistula involving the proximal part of the second portion of the duodenum. A barium enema of the colon showed a duodenocolic fistula with a large abscess cavity at the site of the communication.

On June 6, 1936, abdominal exploration was performed through a right rectus incision. There was a duodenocolic fistula between the second portion of the duodenum and the transverse colon near the hepatic flexure, as well as an extensive, firm, nodular, partially movable malignant mass which involved the colon and duodenum. Side-to-side ileocolostomy was performed. Four weeks later the abdomen was re-explored. The malignant lesion was very extensive and of doubtful operability. Right hemicolectomy was done, involving removal of the terminal portion of the ileum, the cecum, the ascending colon, and the first part of the transverse colon, including a segment of the anterior wall of the duodenum measuring about 6 by 4 by 3 centimeters. The ends of the ileum and the transverse colon were closed and intestinal continuity was re-established by means of antiperistaltic side-to-side ileocolostomy. The duodenum was reconstructed. The pathologic specimen consisted of 20 cm. of ileum, the cecum, the ascending colon, and part of the transverse colon. In the hepatic flexure there was an ulcerative adenocarcinoma, grade 2, which had perforated into the duodenum. The tumor involved the peritoneum but there was no glandular involvement.

The postoperative course was stormy, and by the eighth postoperative day it was evident that an external duodenal fistula had developed. Death occurred on the twenty-third postoperative day. Necropsy revealed extensive bilateral bronchopneumonia and an infarct of the right lung. There was no evidence of generalized peritonitis nor any residual carcinoma.

ANALYSIS OF DATA

The proximity of the duodenum to the right portion of the colon provides an anatomic basis for the occurrence of secondary involvement of the duodenum by a carcinoma of the colon. The second (retroperitoneal) portion of the duodenum is the segment most frequently involved. The process takes place by direct extension of a perforating lesion of the colon. Acute perforation, which occurs infrequently, may be associated with spreading peritonitis. Usually the process is chronic, with adhesion of the adjacent viscera and the formation of a walled-off region. The extent and duration of the lesion determine whether or not an actual fistulous communication is established between the colon and the duodenum.

Reports of cases of duodenocolic fistula resulting from carcinoma of the colon are few. In 1935 Mindline and Rosenheim[1] stated that they were unable to find in recent literature any case of a fistulous opening between the duodenum and the colon resulting from malignant disease. They reported one

case and subsequently others have been recorded by Saleh,[2] Hubeny and Delano,[3] Feldman,[4] and Linton.[5]

The diagnosis of a duodenocolic fistula is usually made roentgenologically. The symptoms do not differ from those of a gastrocolic fistula. Persistent diarrhea and a rapid loss of weight, often accompanied by pain and anemia, are usually present, and the occurrence of fecal vomiting is common. Weber[6] and other observers[3, 4] have pointed out that the fistulous communication is demonstrated better and more frequently with a barium enema than with barium given by mouth.

Cases of operable carcinoma of the right portion of the colon complicated by secondary involvement of the duodenum without formation of fistula, while more common than those cases complicated by fistula, are also decidedly rare. In the period of thirty-nine years from 1907 to 1945, inclusive, in approximately 1,400 cases carcinoma of the right portion of the colon was treated surgically at the Mayo Clinic. There were eight cases of carcinoma of the right portion of the colon with perforation onto or into the duodenum. In the two cases previously summarized duodenocolic fistula had developed. In the remaining six cases the duodenum was involved in the malignant process, but there was no actual fistula. Seven of the patients were men and one was a woman. The youngest patient was a woman of 29 years, the oldest a man of 67 years, and the average age was 49.5 years. The average duration of symptoms before operation was 7.6 months.

The primary lesion involved the hepatic flexure of the colon in five cases, and the cecum or ascending colon in three. The second portion of the duodenum was involved in seven cases, the first portion in one case. Both of the duodenocolic fistulas communicated with the second portion of the duodenum. In every case the lesions were large, ulcerative, perforating adenocarcinomas of either grade 2 or 3, using Broders' classification. It was rather surprising to discover that with lesions as extensive as these there was no involvement of lymph nodes in three of the cases. Regional lymph nodes were involved by metastatic carcinoma in the five remaining cases.

Operative Procedures.—Dr. W. J. Mayo operated on the earliest patient in this series in 1909. He removed a segment of the ascending and transverse colon and re-established continuity of the bowel by means of a side-to-side anastomosis. The carcinoma involved the distal end of the stomach and the first portion of the duodenum. The distal portion of the stomach and the proximal 4 inches (10 cm.) of duodenum were resected in addition to the removal of the colon. This patient lived one year following operation and survived longer following the operation than any other patient in the series. In the remaining seven cases right hemicolectomy and ileocolostomy were performed in each instance. In three of the cases this was done as a two-stage procedure. In these cases ileocolostomy was performed as the first stage and several weeks later the right portion of the colon and terminal ileum were removed as the second stage. In four of the cases the procedure was done in one stage.

With the exception of Mayo's case, local excision and plastic repair (duodenoplasty) were performed in each instance. In one case a portion of the pancreas was also removed.

Survival Time Following Operation.—Of the eight patients, three died while confined to the hospital following operation. One patient died of generalized peritonitis eight days following operation; one died of a pulmonary infarct and bronchopneumonia twenty-three days following operation; and one died, probably from a pulmonary embolism, three days following operation.

Two patients died eight months following operation, and one patient, previously mentioned, survived one year following segmental resection of the colon with partial gastrectomy and partial duodenectomy. One patient (authors' case) is living and well four months following operation, and one patient is living and well nine months following operation for a recurrent carcinoma of the cecum.

COMMENT

The review of these cases of carcinoma of the colon complicated by involvement of the duodenum was undertaken primarily to determine the feasibility of removing segments of the duodenal wall and to study the course of these patients following this procedure. The complication is so unusual that the study would seem warranted. Worthy of mention is the fact that the retroperitoneal portion of the duodenum may be mobilized and subjected to local excision without undue risk or danger of formation of a fistula. As previously mentioned, a fistula occurred in only one of the seven cases in which excision and duodenoplasty were performed. When the second portion of the duodenum is subjected to surgical intervention it is extremely important to safeguard the ampullary structures in dissection. Obviously, if these structures are involved in the malignant process a more radical procedure may be indicated.

Linton[5] has reported two cases of carcinoma of the transverse colon with duodenocolic fistula in which a two-stage procedure was carried out, the second stage being a more radical procedure such as is done for carcinoma in the head of the pancreas. In the first stage the stomach and the ileum were transected and gastrojejunostomy and ileotransverse colostomy were performed. The second stage consisted of a block extirpation of the primary growth with the involved organs (right hemicolectomy and resection of the distal half of the stomach, duodenum, and head of the pancreas with reestablishment of gastrointestinal and biliary continuity). It cannot be denied that this is a more radical procedure and is in keeping with present concepts of surgical treatment of carcinoma in general. However, in neither case was the patient cured by the operation. One patient died eight months after operation and the other had a metastatic mass in the abdomen eight months after operation. The decision as to which procedure to perform, and as to whether the procedure should be in one stage or in two stages, must depend on the individual circumstances present in each case. The age and general condition of the patient, the extent of the lesion, and the involvement of con-

tiguous structures must govern the surgeon in his plan of attack. In recent years, with the adjuvants of preoperative preparation of patients with sulfasuxidine, the intraperitoneal use of sulfonamides, and blood transfusions and penicillin at their disposal, surgeons are tending more and more to do one-stage procedures in many instances of major surgical undertakings which formerly were done in two stages.

SUMMARY

In eight cases, from 1907 to 1945, inclusive, carcinoma of the right portion of the colon, with secondary malignant involvement of the duodenum, has been treated surgically at the Mayo Clinic. The second portion of the duodenum was involved in seven of the eight cases, the first portion in one case. In two of the cases involvement of the duodenum took the form of a duodenocolic fistula. Duodenocolic fistula secondary to malignant disease of the colon is a rare entity and occurs only when the disease is advanced. The lesions were removed in one or in two stages. In seven of the eight cases right hemicolectomy, with local excision of a portion of the duodenal wall and duodenoplasty, was carried out. In the remaining case segmental resection of the colon, with partial gastrectomy and partial duodenectomy, was done. The risk of operation in these cases is high. There were three deaths in the hospital in the eight cases. The prognosis in such cases is unfavorable. The longest survival period following operation was one year.

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THE McARTHUR OPERATION FOR INGUINAL HERNIA

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ATTEMPTS to evaluate the different methods of inguinal herniorrhaphy are difficult to make, and many pitfalls are encountered. Not only must the type of hernia, the type of operation, the experience of the surgeon, the type of suture material, the age and occupation of the patient, and the time of ambulation be considered, but also the care and accuracy with which the follow-up studies are made. Unfortunately, in some published series, part of the follow-up data are based upon mailed replies to questionnaires and not on actual examinations.

For the last four years the senior author and his surgical residents have employed uniformly the McArthur technique for all herniorrhaphies except in children. Indirect and direct hernias have all been treated identically. Since January, 1937, but principally between February, 1941, and November, 1945, the McArthur procedure has been carried out 202 times (including the bilateral hernias), 161 of the operations being done by the senior author and 41 by the surgical residents.

The McArthur technique as employed by us is as follows: Silk is used throughout. The sac is transfixed and ligated and the stump fixed or allowed to retract under the internal oblique muscle. Occasionally, in small direct hernias the sac is unopened. The cord is transplanted. A fascial suture about 4 to 10 mm. wide and about 12 to 15 cm. long is prepared from the mesial border of the split aponeurosis of the external oblique muscle. The fascial suture is left attached at the symphysis pubis. By means of this fascial strip, the "conjoined tendon" and usually the transversalis fascia are approximated firmly to the inguinal ligament by continuous suture. The suture is doubled back from the cord for a few bites, and the end is securely anchored with five or six interrupted No. 00 silk sutures. With the cord still transplanted, the mesial border of the split aponeurosis of the external oblique is sutured with interrupted silk sutures to the inguinal ligament, and the outer layer of the aponeurosis is imbricated over it. The cord is left immediately beneath the skin and subcutaneous fat. The aponeurosis of the external oblique is imbricated above the cord, the lateral flap being uppermost. The opening for the cord is made as small as will permit a Kocher director to be passed easily through it in addition to the cord. For the last thirteen months the patients have been encouraged to get out of bed by the first or second postoperative day and have been sent home on the fourth to eighth day.

The McArthur operation was first described in 1901.[1] In addition to the surgeons listed in Table I, the procedure has been warmly endorsed by Bisgard[2] and by Sachs,[3] the latter employing two fascial sutures. Joyce[4] has used the McArthur operation in about 10 per cent of his cases.[5] Excellent illustrations of the method may be found in the papers by Bisgard[2] and by Ryan.[6]

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In the series of cases here reported, there were 71 indirect hernias, 31 direct hernias, 18 hernias with type not recorded, 7 recurrent hernias, 2 direct-indirect hernias, and 1 hernia without a sac in a total of 112 patients. There were 106 men and 6 women. The average age was 46.6 years, the extremes being 19 and 75 years. Over 175 letters were written requesting the patients to report for follow-up examination. A total of 112 patients actually appeared and were examined by the senior author. The average interval between the time of operation and the follow-up examination was 24.2 months, the extremes being 3 months and 61 months. There were two deaths, one from pulmonary thrombosis and one from pulmonary embolism. There were three cases in which infection developed, and in one of these cases the hernia recurred. Among the seventy-two patients who failed to report for follow-up examination, one was known to have had a recurrence.

TABLE I. MCARTHUR OPERATION

AUTHOR	NUMBER OF OPERATIONS	NUMBER OF RECURRENCES	PERCENTAGE OF RECURRENCES
Lyle[8]	132	8	6.0
Cattell and Anderson[9]	20	1	5.0
Robins[10] (direct only)	27	0	0.0
McCloskey and Lehman[11]	82	3	3.6
McLaughlin[12]	90	0	0.0
Burton[13]	132	6	4.5
Ryan[6]	92	0	0.0
Christopher and Penna	130	4	3.1
Total	705	22	3.1

TABLE II. GALLIE OPERATION

AUTHOR	NUMBER OF OPERATIONS	NUMBER OF RECURRENCES	PERCENTAGE OF RECURRENCES
Cattell and Anderson[9]	125	7	5.6
Burdick and co-workers[14]	975	284	29.1
Keynes[15]	35	0	0.0
Gray[16]	54	4	7.4
Total	1,189	295	24.8

In Tables I to III, unless the quoted series is for direct hernias only, the direct and indirect hernias are grouped together. It is well known that the incidence of recurrence of direct hernia is several times greater than that of indirect hernia. To include them together does not invalidate the basis of comparison. In Table I are shown the results in the McArthur operation; in Table II, in the Gallie fascial transplant method, and in Table III, in a representative group of other methods.

The cases in which recurrence occurred are abstracted as follows:

CASE 1.—Dr. R. S., a white man, aged 53 years, had an indirect hernia. He was operated upon June 15, 1942. There was a recurrence six months later. The second operation was done on June 21, 1943. There was no recurrence following the second operation (follow-up after forty-five months).

CASE 2.—D. D., a white man, aged 67 years, had a large direct hernia with cecum attached to the sac. Operation was done on May 10, 1943. On examination thirty-four months after operation a recurrence with a 3 cm. sac was found. Operation for recurrence was not advised.

TABLE III. NONFASCIAL OPERATIONS

AUTHOR	NUMBER OF OPERATIONS	NUMBER OF RECURRENCES	PERCENTAGE OF RECURRENCES
Erdman[17]	978	72	7.3
Ostfeld[18]	586	31	5.4
Fallis[19]	800	66	8.5
Parsons[20] (chromic gut)	244	31	12.7
Parsons[20] (silk)	458	16	3.5
Shelley[21]	2,126	188	8.8
Blanchard[22]	366	25	6.8
Stein[23]	101	5	4.9
Maingot[24]	500	15	3.0
DeCourcy[25]	220	8	3.6
Total	6,379	457	7.1

CASE 3.—A. B., a white man, aged 47 years, had a right direct hernia. Operation on Oct. 30, 1943, was followed by wound infection with abscess which required incision and drainage (25 c.c. of pus). Ten days before this operation the patient sustained a perforation of the terminal ileum from muscular effort. The perforation was repaired through a right rectus incision on the day of the accident.[7] It is quite probable that a longer interval after the operation at which peritonitis was found should have been allowed before the hernia operation was undertaken. Operation was done for recurrence (above the external ring) on Jan. 22, 1945. No recurrence was noted at a follow-up examination twenty-nine months after the second operation.

CASE 4.—W. R., a white man, aged 61 years, had an indirect hernia. A slight recurrence above the external ring was noted ten months after operation. The condition was unchanged thirty-nine months after operation. The patient was wearing a truss.

SUMMARY

In a series of 130 hernioplasties for indirect and direct inguinal hernia in which the McArthur method of operation was performed, the incidence of recurrence was 3.1 per cent.

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INCISIONAL HERNIA, OPERATIVE TECHNIQUE

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A SURGICAL technique for repair of incisional hernia is presented which reduces operative time, reduces tissue dissection, and gives a firm repair to the hernia. It will also reduce the incidence of postoperative collections of serum because less dissection of the subcutaneous fat is necessary.

An elliptical skin incision is made including the old scar and redundant skin (Fig. 1). Care is taken not to open into the sac while the scar is excised. If the peritoneal cavity is accidentally entered, it is sutured immediately. The left hand then invaginates the sac on one side, coming to rest against the hernial ring. With the hand in this position, an incision is made through the fat about 2 cm. from the edge of the ring (Fig. 2). This incision goes straight down to clean fascia. If the fat pad over the hernial ring is thick, this incision through the fat is made tangentially, the blade facing down and out, so that a relatively thin layer of fat is left over the edge and adjacent area of the ring. In early cases at this hospital, the incision in the fat was made straight down and subsequently trimmed down if invagination of the fat over the sac was difficult. By cutting tangentially when the fat pad is thick, this extra step is eliminated.

With the hand invaginating the hernial sac supporting the wall, the fascia is rapidly cleared of fat for an area of about 4 cm. laterally. An incision is made in the fascia 1 cm. from the medial edge of the fat (Fig. 3). The index finger is inserted in this incision. The fascia here is far enough from the edge of the hernial ring to be free of adhesions and lifts easily. The blade of a pair of curved scissors is then inserted along the finger and the fascia is incised as the finger is advanced (Fig. 4). The same procedure is carried out on the other side. A small strip of fascia 1.5 cm. wide is left intact at both ends (Fig. 5, *E* and *F*).

The outer edge of the strip of fascia which surrounds the ring (Fig. 5, *A*) is sutured to the corresponding edge on the other side (Fig. 5, *A'*), thus folding over the sac the subcutaneous fat that overlies this strip (Fig. 6). In this manner, the subcutaneous fat is converted into preperitoneal fat.

The lateral edges of the incised fascia are then sutured together with overlap (*B* to *B'*, Fig. 7).

If the patient is dieted preoperatively and made to lose weight, we have no difficulty in overlapping the edges (*B* and *B'*, Fig. 7). If overlapping is not possible these edges are merely sutured together. If the gap is too large so that this suturing is not possible without undue tension, then fascial transplants can be used to cover the defect over the rectus muscle (Fig. 6).

There is no doubt that a pedicled fascia transplant is more likely to give good wound healing than a free graft from the fascia lata.

Wangensteen has given us an excellent method whereby we can close these defects in large hernias. If the hernia is in the lower abdomen, the iliotibial tract

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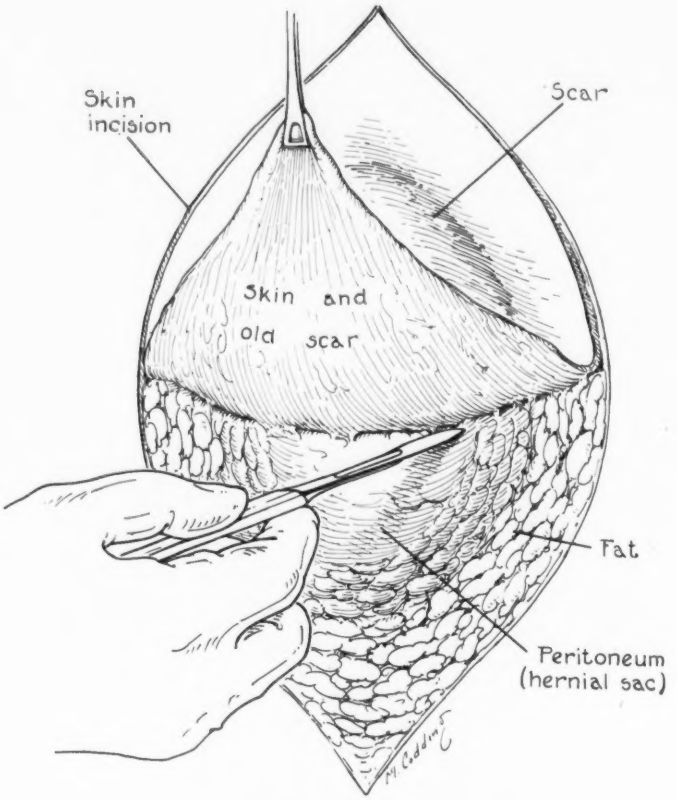

Fig. 1.

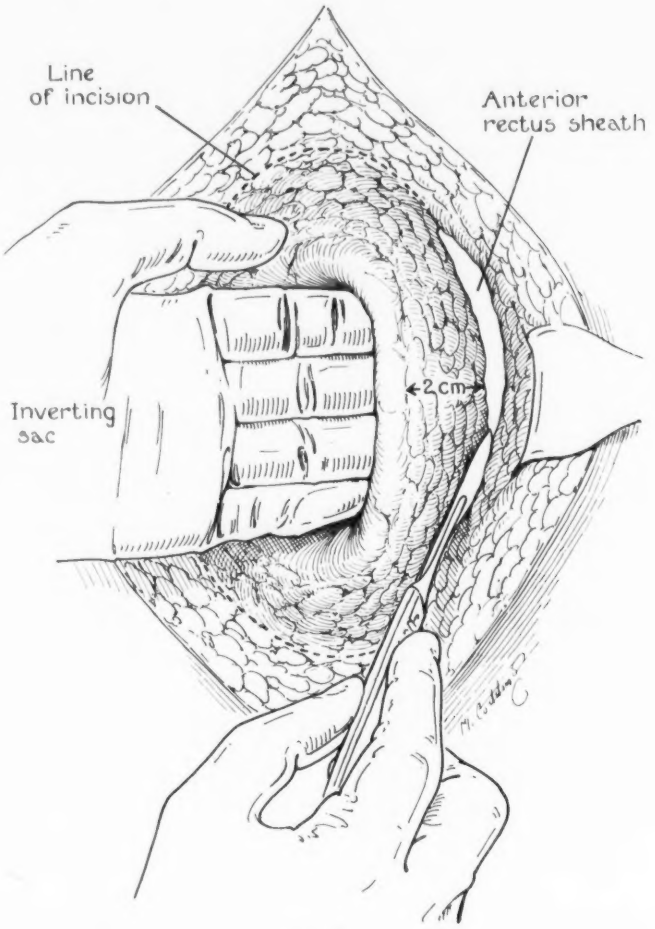

Fig. 2.

Fig. 1.—Elliptical incision including scar and redundant skin. Old scar and skin removed with sharp dissection.

Fig. 2.—No attempt is made to explore the abdomen or to free adhesions of bowel to sac unless there are definite symptoms of obstruction. The gloved hand invaginates the sac, fingers against the edge of ring. A sharp incision is made into the fat 2 cm. from the edge of the ring down to the clean fascia. This incision is extended all around the hernial ring, the inserted hand following the sweeping scalpel.

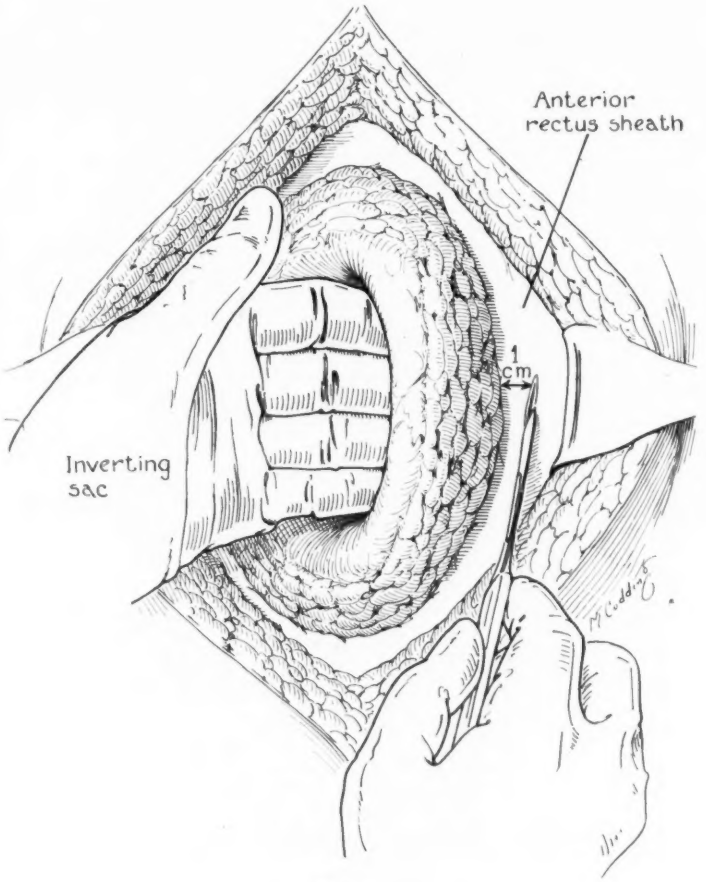

Fig. 3.

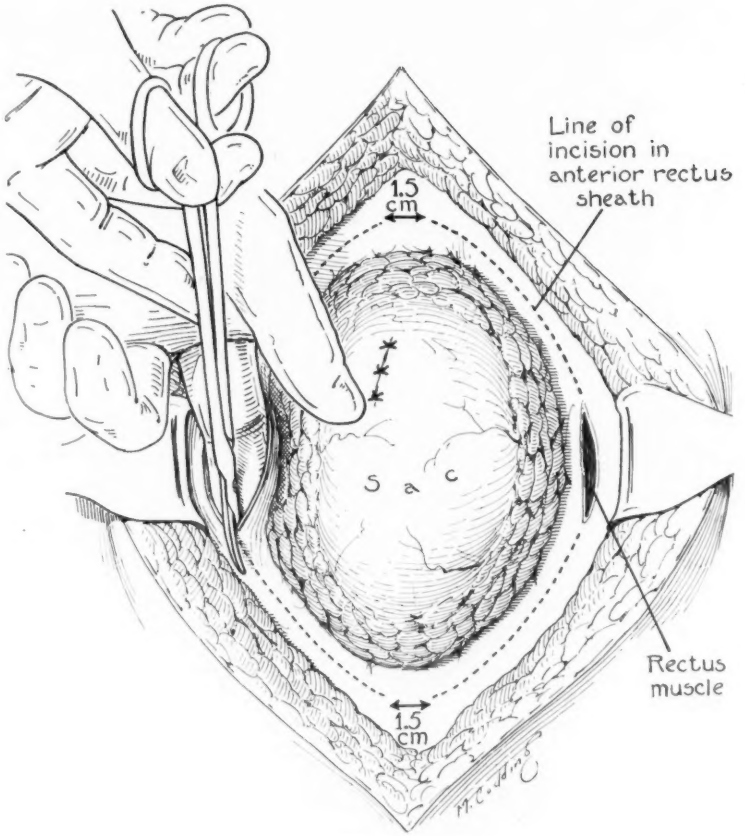

Fig. 4.

Fig. 3.—Gloved fingers are still inserted under the hernial ring. A suitable area of fascia is cleared of fat with the scalpel. An incision is made into the fascia thus exposed, 1 cm. from the medial fat edge.

Fig. 4.—The index finger is inserted under the fascia through the incision just made. The fascia usually lifts easily. A pair of curved scissors along this finger cuts the fascia as the finger is pushed along parallel to the ring.

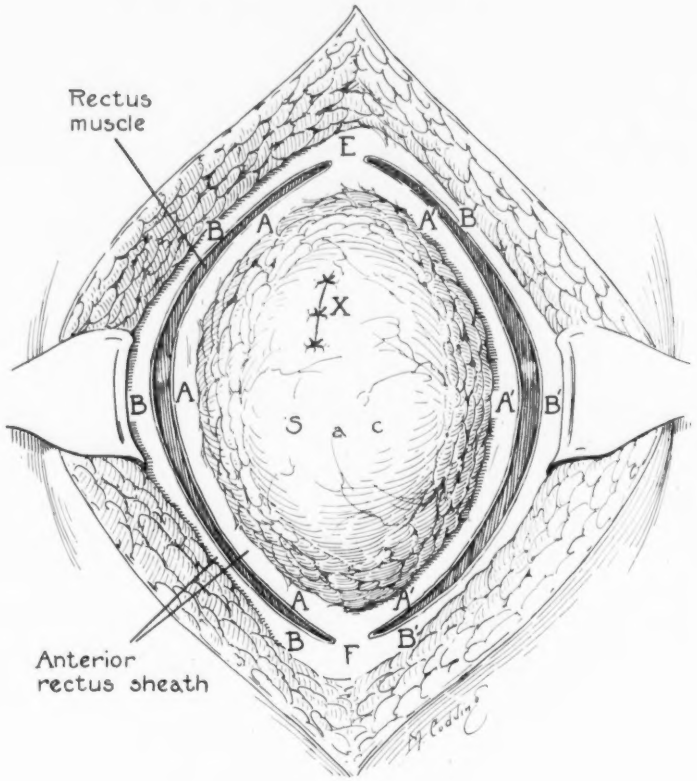

Fig. 5.

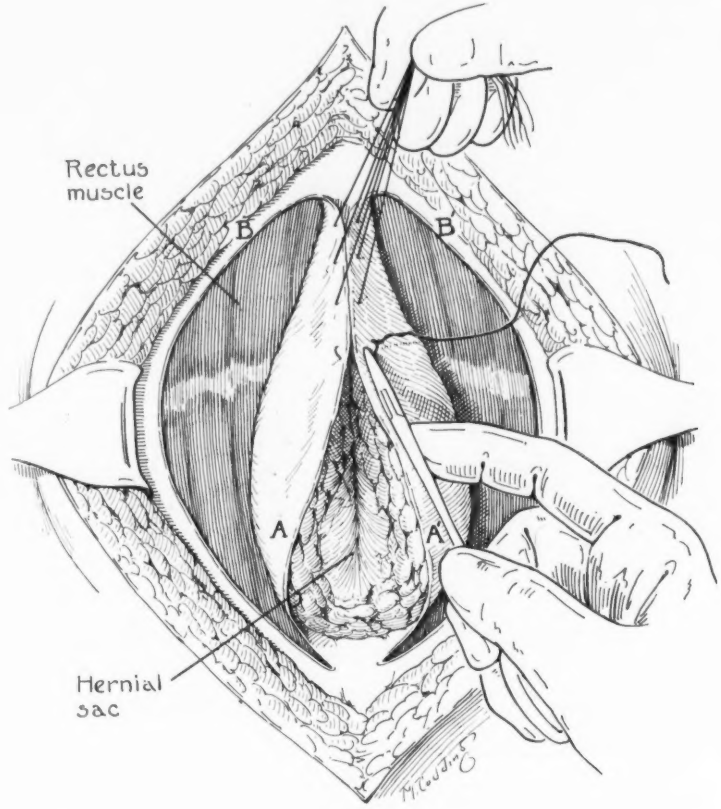

Fig. 6.

Fig. 5.—The incision in the fascia is not carried completely around the ring. An area 1.5 cm. wide is left intact at the upper and lower end, *E*, *F*. The fascial edge *A* is next sutured to edge *A'* as in Fig. 6. *X* shows where the sac was accidentally opened and promptly sutured.

Fig. 6.—Fascial edge *A* is being sutured to *A'*. As this is done, the area of former subcutaneous fat which overlies the hernial ring is turned over and is thus converted into preperitoneal fat overlying the sac. With the completion of suture of fascial edge *A* to *A'*, there is a solid line of fascia over the center of the former hernial sac.

and its lateral extensions of fascia lata are brought over Poupart's ligament into the site of the defect.

A defect in the upper abdomen is closed by Wangensteen's technique of swinging up a fascial flap from the lower abdomen and then covering this latter defect with a pedicled iliotibial tract fascial transplant.

DISCUSSION

By leaving the incised fascia attached at two points (*E* and *F*, Fig. 5), we do not interrupt its continuity with the main fascial plane. Also, after suture of the edges (*A* to *A'*, Fig. 5), we have a solid sling of fascia across the center of the hernial sac (Fig. 7). The blood supply seems to be adequate not only

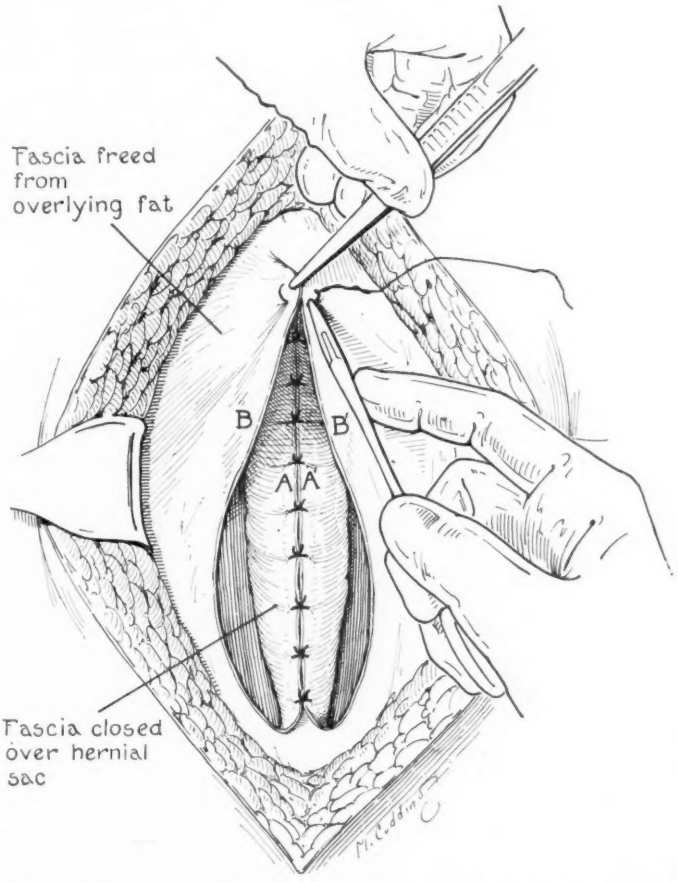

Fig. 7.—Fascial edge *B* is now sutured to *B'* with overlap, thus completing the repair.

for this fascial strip but also for the attached fat that is buried under it. Since none of these patients needed reoperation we cannot say definitely whether this buried fat remained viable as preperitoneal fat or broke down and was replaced by scar tissue. Postoperatively the wounds in this small series healed per primam, except one. This patient, M. M. (Hospital No. 334526), was operated upon June 26, 1940. She had three small defects in the fascia above the main

sac and required dissection and repair of the three small defects before the main defect was repaired with this technique. A moderate amount of serum drained on removal of sutures. However, follow-up study was made until March 26, 1943, when she no longer reported back to the follow-up clinic, and up to that time the scar was firm with no recurrence. In the remaining patients in this small series healing was per primam and there have been no recurrences.

SUMMARY

1. A surgical technique for repair of incisional hernia is presented which reduces fat dissection and operative time.

2. This also gives a firm repair of the hernia.

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ADENOMATOUS GOITER WITHOUT HYPERTHYROIDISM

Surgical Versus Conservative Treatment in Over Two Hundred Patients

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REVIEW of the literature relative to the surgical versus the conservative treatment for nontoxic nodular goiter brings to light conflicting opinions on this question. The two schools of thought are represented in many institutions by the surgery department which advocates surgery in these cases and the medical department which advocates conservative treatment. It was this situation which furnished the stimulus for this paper.

There are several possible indications for surgery in nontoxic nodular goiter:

1. Cosmetic reasons. This is an individual consideration and will not be discussed further.

2. Pressure symptoms. This is largely dependent on the size and position of the goiter and is not a controversial subject.

3. Prevention of the development of carcinoma or the fact that carcinoma may already be present and not recognized. Authorities vary in reports as to the incidence of carcinoma in nodular goiters. Recent studies by Cole and associates[1] suggest that it is higher than generally appreciated and they feel that this incidence is a sufficient indication for surgery, particularly if there is a solitary adenoma.

4. Prevention of the development of toxic nodular goiter. It is difficult to ascertain how many people who have a nodular goiter will eventually develop toxic symptoms. It has been estimated that such toxicity develops in about 50 per cent of these patients.[2]

5. The existence of systemic symptoms even though the basal metabolic rate is normal and the patient is not obviously toxic.

This paper will be concerned with the last two indications.

The problem immediately arises as to what is the criteria for deciding whether a given goiter is toxic or nontoxic. If the patient has an elevated basal metabolic rate, nervousness, palpitation, weight loss, increased appetite, etc., the diagnosis of toxic nodular goiter may be made. If, however, a patient with a nodular goiter has a normal basal metabolic rate, but does have symptoms such as those commonly associated with hyperthyroidism, it is difficult to decide whether this is due to the goiter. The border line between nontoxic and toxic nodular goiter is certainly indistinct. Nevertheless, for purposes of coding records, the diagnosis of one condition or the other must be made. In this paper, our interest is in those patients in whom the diagnosis was made of a nontoxic nodular goiter.

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Many authorities have pointed out that the basal metabolic rate in itself is not a criteria of the toxicity of a goiter. Hertzler,[3] in his recent monograph on thyroid disease, stressed this point and cited his experience with patients on whom follow-up had been carried out for long periods of time and who eventually developed what he called "goiter heart" even though the basal metabolic rate was never found elevated. These patients were greatly improved following thyroidectomy. In 1931, Coller and Arn[4] studied a group of fifty patients who had had a subtotal thyroidectomy during 1927 or 1928. All of these patients had a basal metabolic rate of less than plus 1 prior to operation. A sense of pressure in the neck was present in 44 per cent of these patients. Nervousness was an important symptom in almost every patient. Irritability was associated with this symptom. Palpitation and shortness of breath were complained of by more than one-half of these patients. Other less common symptoms were indigestion, intermittent diarrhea, easy fatigue, and muscular weakness. These authors concluded that nodular goiters associated with basal metabolic rates, in normal and subnormal ranges, can and often do cause systemic symptoms. In most cases these symptoms disappear after the removal of the goiter. Searls[5] in 1936 discussed his experience at the University of California Hospital with a group of patients complaining of nervousness, easy fatigue, palpitation, shortness of breath, and vague gastrointestinal symptoms. These patients were characterized by having a low basal metabolic rate. Removal of the adenomatous goiter resulted in relief of the symptoms in a high percentage of cases. Wetherell[6] pointed out that the use of an elevation in the basal metabolic rate as a criteria for operation in nodular goiter is an unwise practice. In patients having basal metabolic rates ranging from plus 15 to minus 20, in his experience, 85 per cent of the patients suffered from palpitation, about the same percentage suffered from shortness of breath and irritability, and a significant percentage suffered from easy fatigue, excessive dryness of the skin, brittle nails, and cardiac symptoms. He found that cardiac abnormalities were often present. He presented case histories of patients in whom these symptoms were relieved following thyroidectomy. Chesky,[7] in 1939, observed that there was definitely a higher incidence of cardiac abnormalities in a group of patients with nontoxic nodular goiter than in a similar group of patients without a goiter.

There have been very few papers written in opposition to surgical treatment of nontoxic nodular goiter. In 1937, Jackson[8] described 100 cases in which he said needless thyroid surgery had been done. He felt that the surgeon must be certain that the patient is suffering from true hyperthyroidism with its toxic manifestations before he is justified in performing a thyroidectomy. In 1938, Welti and Leven[9] published a paper on useless thyroidectomies.

During the past year, representatives of the surgical and medical departments of other medical schools were contacted in reference to their management of these patients. In a few instances the opinions expressed were those of the individual, while in the rest it represented departmental policies. Twenty-six medical departments expressed the following views: fifteen advised conservative expectant treatment, nine advised surgery in all nodular goiters, and two advised surgery when the patient has reached the age of 35 years. Twenty-four surgical

departments expressed the following views: seventeen advised surgery, five recommended conservative expectant treatment, and two advised surgery when the patient has reached the age of 35 years. There were six instances in which opposing policies existed within the same institution.

CLINICAL STUDY OF UNIVERSITY OF IOWA CASES

All histories of patients on whom a diagnosis of nontoxic nodular goiter had been coded during the years 1938 through 1942 and a few from 1943 and 1944 were studied. These included indigent and private patients. Cases in which there were associated significant disease processes were excluded. All of the patients studied had basal metabolic rates considered to be within normal limits, although it must be admitted that some of these were single determinations. It was the general policy of the medical department not to advise operation in those patients in whom a diagnosis of nontoxic nodular goiter was made. However, some were referred to surgery at their own request and some were advised to have thyroidectomy because of cosmetic reasons or because of pressure effects. Certain patients were admitted directly to the surgery department. There were available for study 181 cases of patients with nontoxic nodular goiter in whom operation was not done and 171 in whom surgery was performed. In studying these case histories the symptoms found were nervousness or irritability, palpation, tachycardia, shortness of breath, and weight loss. It was felt that it would be of interest to do follow-up studies on these patients and ascertain if those in whom partial thyroidectomy was done were relieved of these symptoms, and also to see whether those not operated upon had continued to have symptoms. This was done by questionnaires, therefore the results indicate the way the patient felt about the symptoms and are not a clinician's evaluation of the symptoms.

In all, 374 questionnaires were sent out; 235 were returned. The results are tabulated in Table I.

The average age of patients in the group not operated upon was 45.3 years. The average of those operated upon was also 45.3. In the patients operated upon and likewise in those not operated upon, 93 per cent were women.

Nervousness and Irritability.—Nervousness or irritability was the most frequent symptom and was manifested by 83 per cent of the patients in the group not operated upon on admission and 95 per cent of those operated upon. At the time of the follow-up, 71 per cent of those not operated upon still complained of this symptom while 79 per cent of those operated upon were relieved.

TABLE I

	QUESTIONNAIRES SENT		QUESTIONNAIRES RETURNED	
	NUMBER OF CASES	PER CENT	NUMBER OF CASES	PER CENT
All patients	374	100	235	63
Nonoperated	181	48	94	52†
Operated	171	46	119	70†
Returned by postoffice*	22	6		

*Not included in either group operated upon or not operated upon.
†Refers to per cent returned of questionnaires sent out to this group.

TABLE II. SYMPTOMS ON ADMISSION AND ON FOLLOW-UP

	ON ADMISSION					ON FOLLOW-UP					
	YES		NO		?	YES		NO		?	
	PER CENT	NUMBER OF PATIENTS	PER CENT	NUMBER OF PATIENTS	PER CENT	PER CENT	NUMBER OF PATIENTS	PER CENT	NUMBER OF PATIENTS	PER CENT	NUMBER OF PATIENTS
Nonoperated											
Nervousness or irritability	83	74	17	15	0	71	63	27	24	2	2
Palpitation or tachycardia	84	74	16	14	0	65	57	33	29	2	2
Shortness of breath	73	64	27	24	0	59	52	38	33	3	3
Weight loss	48	42	52	48	0	29	26	71	63		
Operated											
Nervousness or irritability	95	105	5	6	0	16	17	79	83	5	6
Palpation or tachycardia	85	97	15	17	0	21	21	73	72	6	6
Shortness of breath	96	108	4	4	0	18	20	80	88	2	2
			Loss					Gain since operation			
Weight	54	59	43	47	0	74	82	25	28	1	1

? represents patients who did not know how to answer the particular question.

Palpitation or Tachycardia.—Palpitation or tachycardia was present in 84 per cent of the group not operated upon and in 85 per cent of those operated upon on admission. Of those not operated upon 65 per cent reported that they still had pounding of the heart, while in those operated upon, 73 per cent were completely relieved of this symptom.

Shortness of Breath.—In the group not operated upon, shortness of breath was noted in 73 per cent of the patients on admission and in those operated upon, in 96 per cent. Of those operated upon, 80 per cent were relieved while 59 per cent of those not operated upon still reported shortness of breath.

Weight Loss.—Loss of weight was a less frequent symptom. Of the patients not operated upon, 48 per cent reported weight loss on admission and 29 per cent reported continued weight loss at the time of the follow-up. Of those operated upon, 54 per cent reported weight loss before the operation and 82 per cent reported that they had gained weight since the operation.

Patients' Evaluation of Therapy.—In the group not operated upon, 8 per cent of the patients reported that they had improved, 11 per cent had progression of the symptoms, and 68 per cent reported that their condition was essentially unchanged; 13 per cent were equivocal. Of the patients operated upon, 59 per cent were improved, 9 per cent were worse, and 30 per cent were unchanged; 2 per cent were equivocal.

DISCUSSION

There are obvious objections to conclusions that are reached by a questionnaire study of this type. Nevertheless, they do show trends. Our results would

tend to bear out those who contend that the nodular goiter usually referred to as nontoxic is often associated with symptoms of nervousness and irritability, palpitation, tachycardia, and weight loss. These symptoms are present when the basal metabolic rate is within normal limits. On the basis of this study we feel that surgery is indicated in this group of patients and will result in the relief of symptoms present in patients with nontoxic nodular goiters in a significant percentage of cases.

SUMMARY

1. Members of the medical and surgical departments in a series of medical schools were contacted relative to policies of management of patients having nontoxic nodular goiters. Replies were summarized.

2. For this study, 374 questionnaires were sent out to patients previously seen at the University of Iowa Hospitals who had been diagnosed as having nontoxic nodular goiters. Two types of questionnaires were used, one type going to those who had not been operated upon and a second type going to those who had been operated upon.

3. At the time of their admission about three-fourths of all these patients with so-called nontoxic nodular goiters suffered from symptoms often associated with hyperthyroidism in spite of normal basal metabolic rates.

4. Thyroidectomy resulted in regression of these symptoms in a large percentage of cases, whereas little change was noted in the group of patients who were not operated upon, after a period of from one to five years.

5. In one to five years after their discharge, 59 per cent of the group of patients who had operation were improved while 8 per cent of those not operated upon were improved.

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GASTRIC RESECTION FOR PEPTIC ULCER

A Study of 221 Consecutive Cases

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FIVE years ago we reviewed our first experiences with gastric resection for peptic ulcer. That report[1] covered fifty consecutive gastric resections performed between 1927 and 1940 inclusive. From that study three significant facts were apparent to us: (1) our postoperative mortality was too high (28 per cent), (2) our indications for resection were too limited, and (3) our recurrent ulcer rate was too great (14.7 per cent). From the clinical and experimental evidence present in the literature, particularly the work of Wangensteen[2] in this country, it was apparent that we could lower the mortality, widen our indications for resection, and anticipate a lower rate of recurrent ulcer. One hundred consecutive gastric resections for benign ulcer, during the years 1941 to 1943, inclusive, furnish the material for a comparative study. Sufficient time has elapsed to allow an evaluation of the treatment of these cases and to determine to what degree we have attained the previously mentioned objectives.

Sex and Age.—There were eighty-eight men and twelve women in this series. The average age was 49.78 years, the majority of patients (57 per cent) being over 50 years of age. The proportionate number in each age group is shown in Table I.

Symptoms.—The duration of symptoms varied from three months to thirty years, the average being eleven and one-half years. Pain, indigestion, vomiting, and bleeding were the principal symptoms. The frequency of occurrence of these is seen in Table II. Most of the patients had multiple symptoms. Of particular interest were the number who had bleeding and the large number who were unable to work. The symptom of bleeding varied from occasional tarry stools or coffee ground emesis to massive hemorrhage-producing shock. This is a larger incidence of bleeding than is usually reported. In Rienhoff's[3] series hemorrhage as a symptom occurred in 42 per cent of 260 patients subjected to resection for chronic duodenal ulcer. McKittrick, Moore, and Warren[4] reported a history of bleeding in 30.8 per cent of thirty-nine patients who had a two-stage gastrectomy for duodenal ulcer. The degree of invalidism occurring with chronic peptic ulcer and its complications is often not appreciated by the physician. Table II shows that, of eighty patients on whom the information was available, sixty, or 86.2 per cent, were totally unable to work. Another four patients, or 5 per cent, were able to work only part time.

Previous Treatment.—A summary of the previous treatment is shown in Table III. Of the 100 patients, fifty-seven had been treated for their peptic ulcer by the Department of Medicine at the University Hospitals and thirty-six

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TABLE I. AGE

AGE GROUP	NUMBER OF PATIENTS
20 to 29	9
30 to 39	16
40 to 49	18
50 to 59	35
60 to 69	18
70 to 79	4
Total	100

TABLE II. SYMPTOMS

	PER CENT
Pain	99
Indigestion	91
Vomiting	77
Bleeding	64
Weight loss	80
Able to work	
No	86
Part time	5
Full time	9

medically by their local physician. Thus, 93 per cent had been given a trial of conservative therapy before resorting to gastric resection. It is not our intention to define what actually constitutes adequate medical therapy. Based on findings at operation, however, it has been our observation that symptoms of long duration, or frequent recurrence of symptoms, are associated with irreversible pathologic changes which no amount of medical therapy could benefit. We have performed emergency gastric resections for a massive hemorrhage or a free perforation upon patients who were receiving intensive medical therapy. Previous surgical treatment directed at the complications of peptic ulcer had been carried out on thirty of the 100 patients. Many of these operations were performed in our clinic. Table III shows that several of the patients had had more than one operation prior to resection. Twenty-two patients had had a closure of a free perforation, and three of these twenty-two had had a second free perforation.

Primary Indication for Resection.—The primary indication for resection is shown in Table IV. Only the main indication is given, although many had more than one indication such as pain plus bleeding or pain plus obstruction. In the opinion of this clinic, the patient with ulcer who can be well controlled on medical therapy and carry on full-time work is not a candidate for gastric resection.

TABLE III. PREVIOUS TREATMENT

Medical, 93	
University Hospital	57
Local physician	36
Surgical, 30	
Closure perforated ulcer	25
Closure two perforations	3
Gastroenterostomy	8
Excision of ulcer	4
Tearing down gastroenterostomy	1
Pyloroplasty	1

TABLE IV. PRIMARY INDICATION FOR RESECTION

	PER CENT
Pain	39
Obstruction	26
Bleeding	19
Gastric ulcer	7
Wrong diagnosis	7
Free perforation	1
Gastrojejunocolic fistula	1

It is the uncontrolled patient with the complications of intractable pain, obstruction, hemorrhage, or perforation whom we consider for radical resection. Pain was the most common indication for resection, followed closely by obstruction. Bleeding was the reason for resection in 19 per cent of the patients. In eight of these hemorrhage was massive in character and resection was performed as an emergency. In nine patients recent severe hemorrhage had occurred, but no active bleeding was present at the time the operation was performed. In two other patients a marginal ulcer following gastrojejunostomy was the cause of the bleeding. A gastric ulcer which failed to heal under strict medical treatment was an indication for resection in seven patients. Progress in these patients was carefully followed by roentgenographic and gastroscopic examinations. We believe that gastric ulcers should be considered malignant until proved otherwise.

Seven per cent of the patients had an erroneous preoperative diagnosis. The diagnoses had been carcinoma of the stomach in three, cholelithiasis in three, and epigastric hernia in one. An emergency gastric resection was done in one instance for a free perforation of an anterior duodenal ulcer which occurred while the patient was on intensive conservative therapy. A gastrojejunocolic fistula was the indication for resection in one instance.

Location of Pathology.—The location of the pathology is shown in Table V. In ten patients multiple ulcers were present either in the duodenum or stomach or both. A walled-off perforated gastric, duodenal, or jejunal ulcer was present in 59 per cent of the patients. A free perforation was present in one. An active ulcer without local perforation was present in 20 per cent. The remaining 20 per cent showed local stenosis, scarring, and distortion. Of the twenty-six patients resected primarily for obstruction, fifteen had a localized perforated ulcer.

TABLE V. LOCATION OF PATHOLOGY

Duodenal	70
Multiple, 6	
Gastric	21
Multiple, 1	
Gastric and duodenal	3
Marginal (jejunal)	5
Gastrojejunocolic (fistula)	1

Gastric Acidity Studies.—In these 100 gastric resections a definite effort was made to produce postoperative achlorhydria, as determined by gastric analysis after histamine stimulation. For these studies fasting specimens were drawn and histamine phosphate $\frac{1}{44}$ gr. (equaling essentially 0.5 mg. of histamine base)

was administered hypodermically. Samples were then drawn at intervals of fifteen, thirty, forty-five, and sixty minutes after injection. The free hydrochloric acid was determined by titration against a decinormal solution of sodium hydroxide using Töpfer's indicator. A comparison of the average free hydrochloric acid present preoperatively with the average free hydrochloric acid present during the immediate postoperative period and at follow-up examinations was made. The average determinations are shown in Fig. 1. There was essentially no difference in the amount of free acid present in the postoperative period and that present on follow-up examination one year later. The fact that the average determinations after operation show a minimal amount instead of an absence of free acid can be accounted for by an occasional patient who had a

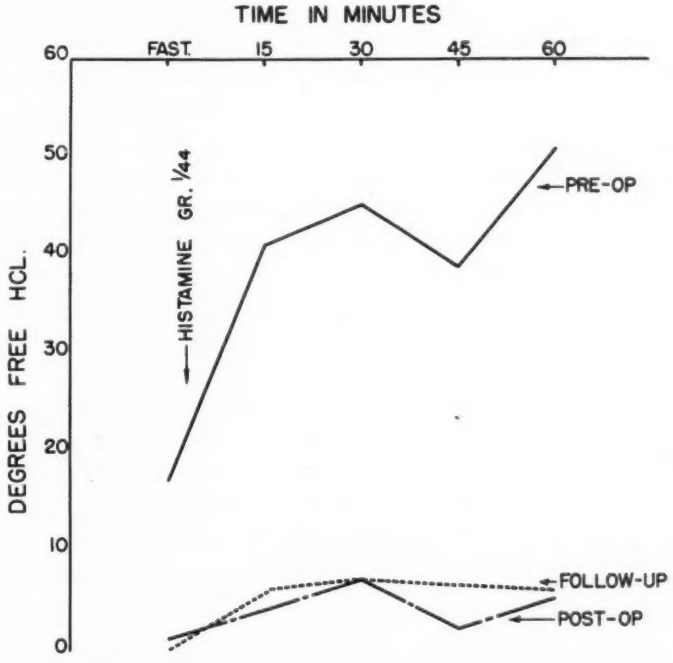

Fig. 1.—Average free hydrochloric acid preoperative, postoperative, and follow up.

moderate amount of free hydrochloric acid present after operation. A few individuals had achlorhydria in the postoperative period but showed some free acid on subsequent follow up, while the reverse was true in a few others. There is no explanation of this change-over in the small per cent of patients where it occurred. Obviously the complete achlorhydria is a relative achlorhydria. There is a small amount of free hydrochloric acid produced by the stomach remnant but this is neutralized by pancreatic juice and bile.

Relation of Amount of Stomach Resected to Reduction of Free Hydrochloric Acid.—Opinions differ among surgeons as to whether radical resection of the stomach is necessary in the surgical treatment of peptic ulcer. Wangensteen[5] favors a three-quarters resection and has presented much clinical and experimental evidence to support his views. He thinks it is best to obtain an achlor-

hydria in all patients. Rienhoff[3] and Heuer and associates,[6] among others, believe that a less radical resection is satisfactory and carries a lower operative mortality. Heuer and associates[6] have stated that achlorhydria postoperatively is not necessarily related to a good result.

Because of these divergent opinions an attempt was made to determine in these 100 patients the relation of the amount of stomach removed to the reduction in acidity and to the clinical end result. In 80 per cent of the patients, two-thirds or more of the stomach was resected. The remaining 20 per cent, who had conservative resections, were operated early in the series when we were formulating our opinions. Of the eighty cases, nine had a four-fifths resection, twenty-eight a three-quarters resection, and forty-three a two-thirds resection. The portion of stomach removed was not weighed or measured, the amount removed being estimated by the surgeon. In Table VI are shown the results of gastric analyses performed on follow-up examination of the patients who had radical resections. Fifty-six of the eighty patients had gastric analyses available for comparison, and of these forty-one, or 73 per cent, had achlorhydria after histamine stimulation. The average age of the groups of patients shown in Table VI indicates that an attempt was made to be more radical in the younger individual. It is of interest that there was a greater percentage of patients with achlorhydria among those who had a two-thirds resection than in those who had a three-quarters resection. The explanation of this finding is not apparent. The recent studies of Wangensteen[5] in regard to a short afferent loop may be of importance here. Unfortunately the length of the afferent loop was not measured. We favor a short afferent loop because we think it gives a better functioning anastomosis. It is possible to use a shorter afferent loop after two-thirds resection than after a more radical resection. If one assumes that a shorter afferent limb was utilized after two-thirds resection than after three-quarters resection, then possibly the shorter proximal limb of the anastomosis becomes more important in producing a relative achlorhydria than the difference between removing two-thirds or three-quarters of the stomach. We are making an investigation of this problem at the present time.

TABLE VI. RELATIONSHIP OF AMOUNT OF STOMACH RESECTED TO REDUCTION OF FREE HCL

AMOUNT RESECTED	NUMBER OF PATIENTS	NUMBER AVAILABLE FOR STUDY	AVERAGE FOLLOW-UP GASTRIC ANALYSIS (DEGREES FREE HCl)				NUMBER ACHLORHYDRIC	PER CENT ACHLORHYDRIC	AVERAGE AGE (YEARS)
			FAST	15 MIN.	30 MIN.	60 MIN.			
Four-fifths	9	5	0	0	5	0	4	80	41.8
Three-fourths	28	21	1	7	9	8	14	66⅔	46.9
Two-thirds	43	30	0	5	4	1	23	76⅔	50.0

Method of Operation.—All gastrojejunal anastomoses were of the terminolateral, oralis totalis type. Ninety-nine were retrocolic and one antecolic. An associated enteroenterostomy was performed in five instances, one in the antecolic and one in a classical retrocolic anastomosis. The other three enteroenterostomies were of the en-y type, performed after jejunal resection for a marginal ulcer. We believe that associated enteroenterostomy is unnecessary

and may predispose to recurrent ulcer. Resection with pyloric exclusion and removal of the antral mucosa was performed in four patients. This reflects our opinion that so-called "irremovable" duodenal ulcers are not common. In most instances of perforating posterior duodenal ulcers we remove the ulcer and dissect free sufficient posterior duodenal wall for adequate closure. The closure of the pyloric stump after pyloric exclusion has not been satisfactory in our experience. In none of our cases have we felt it necessary to place a T tube in the common bile duct for identification of this structure, as advised by Lahey.[7] Recently we have closed the duodenal stump in two patients by the method described by Wangensteen[8] and Nissen.[9] By this technique the anterior duodenal wall is inverted into the posterior duodenal wall without mobilizing the latter. It obviates possible damage to the retroduodenal structures.

Nonfatal Postoperative Complications.—Thirty-one per cent of the patients had major, nonfatal postoperative complications. These are listed in Table VII. Nine, or 29 per cent, of the complications were pulmonary. Five patients had primary wound infections. It was necessary that one patient be reoperated because of an obstructed anastomosis; an anterior gastrojejunostomy and enteroenterostomy was performed twenty days after resection. In three patients there was delayed function of the anastomosis; however, all of these cleared up with gastric suction. One patient developed symptoms and findings of incomplete obstruction of the small intestine which responded to conservative treatment. In two patients the lesser pancreatic duct was divided at operation. In one of these cases there was a marginal ulcer and an associated posterior duodenal ulcer perforated into the pancreas. In the other there was a perforated lesser curvature pyloric ulcer with a walled-off abscess cavity containing 200 c.c. of pus and gastric contents. A temporary pancreatic fistula developed in both instances but closed spontaneously. Temporary jaundice was the main complication in two patients. In these the icterus was due to intraperitoneal sulfanilamide implanted at operation. No jaundice occurred in fifty-nine other patients in whom intraperitoneal sulfonamides were used. Wound separation without evisceration, not requiring secondary closure, occurred in two patients. Another patient had an evisceration closed by secondary suture. An intra-

TABLE VII. MAJOR POSTOPERATIVE COMPLICATIONS (NONFATAL)

Pneumonia	7
Atelectasis	2
Wound infection	5
Delayed function of anastomosis	3
Obstructed anastomosis (reoperated)	1
Incomplete intestinal obstruction	1
Laryngeal Edema (tracheotomy)	1
Temporary pancreatic fistula	2
Jaundice	2
Wound separation (without evisceration)	2
Evisceration (secondary closure)	1
Intra-abdominal abscess (drainage)	2
Ascites (reoperated)	1
Bleeding from gastrointestinal tract	1
Total	31

abdominal abscess, requiring drainage, occurred in two patients. One patient developed marked ascites requiring repeated paracentesis. On reoperation aseptic necrosis of a portion of the great omentum was found. Bleeding from the gastrointestinal tract continued for ten days after resection in one patient. Laryngeal edema, a complication of the intratracheal anesthesia, occurred in one patient and required that a tracheotomy be performed.

Mortality.—There were eight deaths. Five of these occurred in the group of twenty patients having less than two-thirds of the stomach removed, while the other three deaths were in the group of eighty patients who had two-thirds or more of the stomach removed. From this it would appear that the magnitude of stomach resection per se does not increase the mortality rate. In four of the eight patients the indication for resection was a serious complication of ulcer or of the previous inadequate surgical treatment. Two of these underwent emergency resection for massive hemorrhage, one was resected for a marginal ulcer, and one for a gastrojejunocolic fistula, both of which followed gastroenterostomy.

The other four patients who died had elective resections for pain or obstruction. In two, cardiac failure was the cause of death, while peritonitis was responsible for the other two deaths.

The average age of the eight patients who died was 60.2 years in contrast to the average age of 49.78 years of the entire series. We do not think that the elderly patients should be denied the benefit of gastric resection because of the age factor alone. Reports of the eight postoperative deaths follow.

CASE REPORTS

CASE 30.—J. B. (hospital No. 39-13124), a 58-year-old white man, had a gastrojejunostomy performed in this hospital Feb. 21, 1940, for duodenal ulcer. He developed recurrence of pain and bleeding. He had a severe case of asthma and had a marked anemia. The latter required seven blood transfusions before operation. Indication for resection was marginal ulcer with pain and bleeding. Operation was done on June 24, 1942. A marginal ulcer, 1 cm. in diameter, was found in the jejunum opposite the stoma. Three-fifths of the stomach was removed. A postcolic, terminolateral, oralis totalis gastrojejunostomy re-established the continuity of the gastrointestinal tract. A resection of the jejunum containing the ulcer was considered but the idea was abandoned and the jejunal opening closed, the new jejunal stoma being made distal to the site of closure. After resection the patient developed atelectasis. He developed a wound separation and this was followed by a jejunal fistula. On Oct. 1, 1942, he was reoperated and the fistula containing segment of jejunum (in the afferent limb) was resected and an end-to-end anastomosis performed. This jejunal anastomosis broke down. He became weaker and died on Oct. 19, 1942, eighteen days after jejunal resection and 118 days after gastric resection. Autopsy revealed jejunal fistula and left subphrenic abscess.

Comment.—It would have been better to have resected the involved jejunum at the time of gastric resection.

CASE 47.—G. O'N. (hospital No. 42-13166) was a 68-year-old white man. Fifteen years before admission he was treated medically for "ulcers" and recovered. He developed recurrence of pain six weeks before admission and had tarry stools and severe episodes of hematemesis, which required hospitalization the week before entrance to our service. On admission the hematemesis had ceased but he had tarry stools. Blood studies revealed a

hemoglobin of 3.8 Gm., and the red blood cell count was 1,900,000 per cubic millimeter. The patient was given nothing by mouth, morphine ¼ gr. by hypodermic, and three 500 c.c. blood transfusions. Because the hematemesis had subsided and because of the severe anemia, we decided to try conservative treatment to build him up for elective resection. However, the following day, Nov. 15, 1942, he had a massive hematemesis, accompanied by shock. An emergency operation revealed a perforated posterior duodenal ulcer with an actively bleeding artery in the ulcer crater. The bleeding vessel was controlled by transfixion suture. The ulcer-bearing area of the duodenum and 50 per cent of the stomach were removed. Gastrointestinal tract continuity was re-established by a postcolic, terminolateral, oralis totalis gastrojejunostomy. Postoperatively the patient was given 2,500 c.c. of blood. On Nov. 18, 1942, he eviscerated and secondary closure was performed. He died on the operating table. Autopsy revealed localized peritonitis, wound infection, pleural effusion, and pulmonary edema. The duodenal stump closure and gastrojejunal suture lines were intact.

Comment.—The ideal time for resection was when he had his first bleeding. A patient who has lost large amounts of blood over a period of time is a poor operative risk even though supported by many transfusions.

CASE 52.—C. C. (hospital No. 42-13156), a 57-year-old white man, had had symptoms of ulcer and vomiting for twenty years. Stools had been tarry for one week. He had chronic heart disease and was receiving digitalis. Indications for resection were continued pain and a large gastric ulcer not controlled by conservative treatment. Operation was done on Nov. 20, 1942. A posterior gastric ulcer, perforated into the pancreas, was found. The proximal duodenum and three-fifths of the stomach were removed. Continuity of the gastrointestinal tract was re-established by a postcolic, terminolateral, oralis totalis gastrojejunostomy. Twenty-four hours after operation the patient developed clinical signs of cardiac failure. He failed to respond to treatment and died on the sixth postoperative day. Clinical cause of death was cardiac failure. Autopsy was not granted.

Comment.—This patient had continuous severe pain which could not be relieved by the most strict conservative measures. For this reason gastric resection was indicated even though he had severe heart disease.

CASE 63.—M. I. (hospital No. 42-14384), a 68-year-old white man, had had symptoms of ulcer, chiefly pain with occasional episodes of vomiting, for twenty-eight years. Indication for resection was increasing pain in spite of conservative treatment on the medical service. Operation was done on Feb. 5, 1943. Exploration revealed a very active duodenal ulcer along the superior border, with stenosis distal to the ulcer, considerable scarring, and inflammation in the periduodenal tissues. Resection of one-half of the stomach, with exclusion of the pylorus and removal of the antral mucosa, was performed. It was felt that removal of the involved duodenum might result in damage to the common bile duct. Twenty-four hours after operation he developed fever and right upper abdominal pain. On Feb. 12, 1943, a right subhepatic abscess was drained. The patient died on Feb. 13, 1943. Autopsy revealed generalized peritonitis due to necrosis and leakage of pyloric stump, subhepatic and subphrenic abscesses, bilateral empyema thoracis, and bronchopneumonia.

Comment.—In difficult posterior duodenal ulcers we have usually mobilized the duodenum for closure. We have preferred this method because of the difficulty in obtaining a secure closure of the pyloric stump after exclusion and removal of the antral mucosa. However, recent studies and improvements in our technique of pyloric stump closure lead us to believe that this method may be used without undue danger.

CASE 70.—M. T. (hospital No. 40-8113), a 54-year-old white man, had had symptoms of ulcer for thirty years. He had had medical treatment at another clinic, by several local

physicians, and by the medical department of this hospital. He was first admitted to the surgical service in 1940, at which time an acute perforation of a duodenal ulcer was closed. Persistent postoperative vomiting ensued and a posterior gastrojejunostomy was performed. Ten months before the last admission to the surgical service the patient began to have hematemesis and tarry stools. Four months before admission he developed diarrhea and foul breath and began to have bowel movements immediately after eating. A barium enema revealed a gastrojejunocolic fistula. A double-barreled colostomy, utilizing the right transverse colon, was performed on Feb. 19, 1943, as a preliminary measure to resection. The second stage was delayed until April 9, 1943, because he developed lobar pneumonia. At the second operation the jejunum distal to the old gastrojejunostomy was found adherent to the colon. A moderately large fistula was present between the colon and jejunum just distal to the anastomosis. There was a posterior duodenal ulcer perforated into the pancreas. The old gastrojejunostomy was disengaged and the colonic fistula closed. The ulcer-bearing area of the duodenum and three-quarters of the stomach were removed. The jejunal stoma and fistula were converted into one opening, which allowed it to be used for the new jejunal stoma. Continuity of the gastrointestinal tract was then re-established by a postcolic, terminolateral, oralis totalis gastrojejunal anastomosis. Postoperatively the patient developed fever, jaundice and abdominal pain, tenderness, and rigidity. He became weaker and died on April 17, 1943. Autopsy revealed generalized bile peritonitis due to a defect and traumatic stricture of the common bile duct, atelectasis, and left perinephritic abscess.

Comment.—This case is the only proved one of operative injury to the common bile duct.

CASE 74.—P. H. (hospital No. 43-4045), a 68-year-old white man, had had symptoms of ulcer for forty years. He also had severe pain, occasionally requiring morphine, vomiting, and hematemesis, for three weeks before admission. He had been in a local hospital during this three-week period. On admission to our service, April 20, 1943, blood studies revealed the hemoglobin to be 4.3 Gm., and the red blood cells were 1,590,000 per cubic millimeter. A gastric series taken the day after admission revealed pyloric obstruction, probably due to a duodenal ulcer, with 90 per cent gastric retention. On April 22, 1943, the stomach was aspirated and 1,300 c.c. of coffee ground material obtained. On April 23, 1943, he had a massive hematemesis accompanied by shock; the hemoglobin was less than 7 Gm., and the erythrocytes were 1,590,000 per cubic millimeter. An emergency gastric resection seemed indicated because of recurrent massive bleeding. The patient was given a total of 3,000 c.c. of blood before and during the operation. On exploration anterior and posterior kissing duodenal ulcers were found. The anterior ulcer was of the perforating type, and the posterior one had perforated through the duodenal wall into the pancreas. A vigorously bleeding artery was present in the ulcer crater and was controlled by transfixion sutures. A 900 c.c. blood clot was removed from the stomach. There was marked scarring and stenosis of the duodenum distal to the ulcers. The involved duodenum and one-half of the stomach were removed. Continuity of the gastrointestinal tract was re-established by a postcolic, terminolateral, oralis totalis gastrojejunostomy. At the beginning of the operation the blood pressure was 60 mm. Hg systolic and 40 mm. Hg diastolic. At the conclusion of the operation the blood pressure was 90 mm. Hg systolic and 50 mm. Hg diastolic. In the immediate postoperative period he received two additional 500 c.c. blood transfusions. On the second postoperative day he became jaundiced; the van den Bergh reaction was 20.0 direct. Five additional 500 c.c. blood transfusions were given during the postoperative period. The course was febrile, the patient became weaker, and death occurred on May 1, 1943, on the ninth postoperative day. Autopsy revealed generalized peritonitis due to separation of gastrojejunal suture line, cellulitis of abdominal wall, right bronchopneumonia, left lower lobe atelectasis, and bilateral pleurisy and pericarditis.

Comment.—Poor healing related to the great blood loss was responsible for the separation of the suture line and fatal peritonitis. The blood trans-

fusion service quite definitely determined that the jaundice was due to the transfusion of excessive amounts of free hemoglobin. This case is similar to Case 47, in that massive bleeding occurred while the patient was being prepared for elective resection. This type of patient is a notoriously poor operative risk. Earlier operative intervention, before succeeding exsanguinating hemorrhages occur, will give a lower operative mortality.

CASE 79.—C. S. (hospital No. 43-5356), a 37-year-old white man, had had symptoms of ulcer, chiefly pain and vomiting, for one year. Gastric series showed a stenosing duodenal ulcer with 100 per cent retention in five hours. Indication for resection was obstruction and pain which was unrelieved by conservative treatment on the medical service. Operation was done on June 16, 1943. At operation multiple duodenal ulcers, two anterior and one posterior, with marked duodenal stenosis were found. The involved duodenum and two-thirds of the stomach were removed. Gastrointestinal tract continuity was re-established by a postcolic, terminolateral, oralis totalis gastrojejunal anastomosis. On the fourth postoperative day the patient began to develop noticeable jaundice. On June 30, 1943, a left subhepatic abscess, containing 900 c.c. of fluid that appeared to be bile, was drained. No organisms grew out of this fluid on culture. On July 4, 1943, 8 liters of bile-stained fluid were removed from the abdomen by paracentesis. On July 8, 1943, the right subphrenic and subhepatic areas were explored, by anterior approach, and 4,000 c.c. of bile-stained fluid removed. A fibrin-covered mass in the gall bladder area was aspirated and 6 c.c. of pus obtained. This latter material yielded *Escherichia coli* on culture. The patient became weaker and died on July 19, 1943. Clinical cause of death was bile peritonitis, due to possible rupture of the gall bladder, common bile duct, or other extrahepatic ducts, and possible suppurative pancreatitis. Autopsy was not granted.

Comment.—This case definitely did not appear like one with a blowout of the duodenal stump. This we believe represents our second operative injury to the common duct which caused a blowout in the extrahepatic system.

CASE 97.—J. E. (hospital No. 43-12091), a 72-year-old white man, had had symptoms of ulcer, chiefly pain and vomiting, for two years. A gastric series showed what appeared to be a duodenal ulcer with 90 per cent retention in six hours. Indication for resection was obstruction. Operated on Nov. 23, 1943. Exploration revealed a posterior pyloric ulcer perforated into the pancreas. The ulcer crater in the pancreas measured 4 cm. in diameter. There was a small abscess on the superior surface of the duodenum with marked duodenal stenosis. The involved duodenum and two-thirds of the stomach were removed. Gastrointestinal tract continuity was re-established by a postcolic, terminolateral, oralis totalis gastrojejunostomy. Postoperatively the patient developed cardiac failure which failed to respond to treatment and died on Nov. 28, 1942. Autopsy revealed left-sided cardiac hypertrophy and marked pulmonary emphysema.

Comment.—Aged patients with poor cardiac reserve may be accepted for resection when the disease cannot be controlled by conservative measures.

RESULTS

There were ninety-two patients available for follow-up studies. Fifty-nine, or 64.1 per cent, were followed by examination at the hospital or by letters to the patients. There were fifty-two in the former and seven in the latter group. Most of the remaining patients were followed indirectly by information obtained from the local physician. The results were classified in three groups: well, improved, or recurrent. To be classified as well a patient must have been free of all ulcer symptoms, eating well and working full time, or carrying on normal

daily life. The improved classification signified that the patient was free of pain and all other ulcer complaints, but other symptoms, such as weakness or poor appetite, were present. Any patient who had recurrent symptoms after resection, such as pain, hemorrhage, distress, or vomiting, was classified as having recurrent ulcer, regardless of whether it could be demonstrated by roentgenographic examination. A stringent classification of results must be adopted if we are to evaluate properly the place of gastric resection in the treatment of peptic ulcer.

The fifty-nine patients who were followed directly were classified as follows: well, fifty-one, or 86.4+ per cent; improved, four, or 6.7+ per cent; recurrent, four, or 6.7+ per cent. There was no evidence of recurrent ulcer in any of the thirty-three patients followed indirectly. Reports from the local physician usually stated that the patient was well and working and did not care to return for a checkup examination. Due to the method of handling the care of patients in this state clinic, most of the patients treated by us who later develop complicaions are returned to us for further care.

Studies of the possible cause or causes of recurrence in four patients are of interest. Pertinent information regarding these cases is shown in Table VIII and in the case reports. In two of the patients, Cases 14 and 68, we feel that removal of an inadequate amount of stomach was the cause of the recurrence. In the other two, Cases 50 and 75, the answer is not so apparent. Both of these had three-quarters resections which would appear to be adequate to forestall the development of a recurrent ulcer. However, both of these patients were resected because of marginal ulcer, and resection of the portion of the jejunum containing the ulcer was required. Gastrointestinal tract continuity was then re-established by closing the end of the distal jejunal segment and anastomosing

TABLE VIII. RECURRENCES

CASE NO. PATIENT	AGE	INDICATION FOR RESECTION	AMOUNT OF STOMACH RESECTED	TYPE OF ANASTOMOSIS	FOLLOW-UP GASTRIC ANALYSIS				COMMENTS
					FAST	15	30	60	
14, C. V.	54	Recent severe bleeding	2/3	Polya	–	–	–	–	Marginal ulcer; died two years and eight months after resection with gastrojejunocolic fistula
50, R. McC.	60	Marginal ulcer	3/4	Polya resection jejunum en-y	0	44	64	38	Symptoms of marginal ulcer
68, L. M.	56	Recent severe bleeding	1/2	Polya	0	0	27	34	Marginal ulcer; under conservative treatment twenty-six months after resection
75, E. T.	45	Marginal ulcer	3/4	Polya resection jejunum en-y	10	41	55	73	Died of hemorrhage and local perforation of marginal ulcer twenty-five months after resection
				Average	3	28	49	48	

it to the stomach by the terminolateral, oralis totalis method. The end of the proximal jejunal segment was then anastomosed, end to side, to the distal jejunal segment distal to the gastrojejunal anastomosis. On the basis of Wangensteen's[5] recent report regarding the function of the short afferent loop, these recurrences may be blamed on the en-y type of jejunojejunostomy. It would appear essentially impossible for the free hydrochloric acid from the remaining gastric pouch to reach the duodenal mucosa and thus stimulate the production of secretin. Furthermore, the buffering effect of the alkaline bile and pancreatic juice that is secreted is lost, since these juices by-pass the gastrojejunal anastomosis, leaving it exposed to the acid-peptic digestive juice. One other patient, resected for a marginal ulcer, had a two-thirds gastric resection with resection of the jejunum and this same type of en-y jejunojejunostomy.

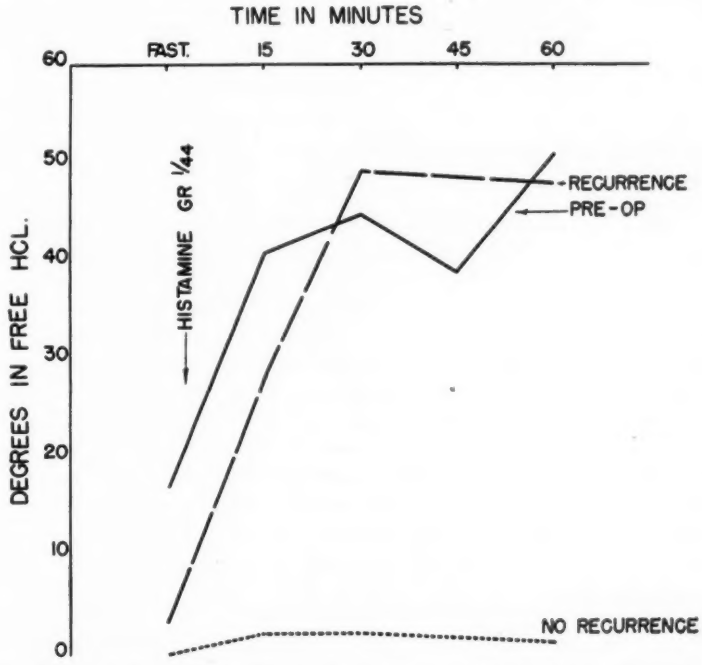

Fig. 2.—Comparison of the free hydrochloric acid in patients with recurrent ulcer and in patients without recurrence. For clarity the average preoperative acid curve is included.

Follow-up determinations of the amount of free hydrochloric acid, after histamine stimulation, are available in three of the four patients with recurrent ulcer. Case 14 had a personal checkup but unfortunately gastric analysis was not done. Case 50 was examined in our clinic five months after operation and a gastric analysis was done. He was well at that time, but fifteen months later his local physician reported him to be under treatment for a marginal ulcer. In Fig. 2 is shown the preoperative free hydrochloric acid curve compared with the free hydrochloric acid curves of the patients with recurrent ulcer and those with no recurrences. It is noted that the free acid curve of the patients with recurrent ulcer is as high, or higher, than the preoperative curve. This indicates that the acid values in recurrent ulcers are essentially the same as the values

obtained preoperatively when the original ulcer was present and that a relative achlorhydria is necessary to prevent recurrence.

A direct relationship between recurrent ulcer and conservative resection is evident in this series. In twenty patients who had less than a two-thirds resection, a recurrent ulcer developed in two of the fifteen survivors, a recurrence rate of 13.3 per cent. In eighty patients who had two-thirds or more of the stomach resected, recurrent ulcer developed in two of the seventy-seven survivors, a recurrence rate of 2.59 per cent.

During the same years, 1941 to 1943 inclusive, there were eleven patients treated for ulcer by gasteroenterostomy. Nine of these were done in 1941, one in 1942, and one in 1943. Recurrent ulcer developed in three of the eleven patients, a recurrence rate of 27.3 per cent. Reports of the four patients with recurrent ulcer are as follows.

CASE REPORTS

CASE 14.—C. V. (hospital No. 42-551), a 54-year-old white man, had had symptoms of ulcer, consisting of severe pain with nausea and vomiting, for three months. He had a massive hemorrhage six weeks before admission. On entrance he showed a severe anemia which required three blood transfusions before operation. Indications for resection were recent severe bleeding and continued pain. Operation was done on Jan. 22, 1942. Exploration revealed anterior and posterior duodenal ulcers; the posterior one was perforated into the pancreas. The ulcer-bearing area of the duodenum and two-fifths of the stomach were removed. Gastrointestinal tract continuity was re-established by a postcolic, terminolateral, oralis totalis gastrojejunostomy. The postoperative course was uneventful and the patient was discharged on the fifteenth postoperative day. He was readmitted to the hospital on Feb. 13, 1943. He had had recurrence of severe ulcer pain, with vomiting, indigestion, weakness, and weight loss. Gastric series showed the anastomosis to be functioning well; there was no evidence of marginal ulcer. However, we felt that he did have a marginal ulcer despite negative roentgenographic findings. The patient was placed on medical management for a week and then discharged to the care of his home physician. He continued to have recurrent symptoms. In September, 1944, he entered another hospital with evidence of a gastrojejunocolic fistula. While he was being prepared for surgery an ulcer was perforated and the patient died several days after an emergency exploration.

Comment.—This recurrence was due to removal of an inadequate amount of stomach. A resection should have been performed in February, 1943, when we first diagnosed the marginal ulcer.

CASE 50.—R. McC. (hospital No. 42-13182), a 60-year-old white man, had had symptoms of ulcer for sixteen years. He had a gastroenterostomy performed in this clinic in 1936. This was followed by recurrence of pain and five episodes of bleeding. Indication for resection was recent severe hemorrhage and marginal ulcer. Operation was done on Nov. 18, 1942. Exploration revealed a jejunal ulcer opposite the stoma, which had perforated into the jejunal mesentery. A posterior duodenal ulcer, perforating into the pancreas, was also present. The ulcer-bearing area of the duodenum, three-fourths of the stomach, and a 6-inch segment of jejunum were resected. A postcolic, terminolateral, oralis totalis gastrojejunostomy and en-y jejunojejunostomy re-established the continuity of the gastrointestinal tract. A complication of the operation was the inadvertent division of the lesser pancreatic duct. Postoperatively there was drainage of pancreatic juice from the abdominal wound but it subsided spontaneously. Gastric analysis after operation showed 38 and 52 degrees of free hydrochloric acid at intervals of thirty and sixty minutes, respectively, after histamine. The patient was discharged on the forty-third postoperative day. He returned for examination five months

later. He had gained 20 pounds in weight. His strength was fair and he was working half time. He had no ulcer symptoms. Gastric analysis was done and the results are seen in Table VIII. Gastric series showed a normally functioning stoma without evidence of a marginal ulcer. Four months later a letter from the local physician reported that the patient had symptoms of a recurrent ulcer and was on medical management.

Comment.—We think that the recurrent ulcer was due to the en-y type of enteroenterostomy carried out in conjunction with the gastrojejunostomy.

CASE 68.—L. M. (hospital No. 43-2198), a 56-year-old white man had had symptoms of ulcer, essentially pain, in the spring and fall, for fifteen years. He had had four moderate to severe episodes of bleeding, the most recent occurring nine days before admission. Indication for resection was recent severe bleeding. Operation was done on April 1, 1943. A posterior duodenal ulcer, perforating into the pancreas, was found. The ulcer-bearing area of the duodenum and one-half of the stomach were removed. A postcolic, terminolateral, oralis totalis gastrojejunostomy was performed. The patient was discharged on the thirteenth postoperative day. He was readmitted to the hospital June 21, 1944. He complained of episodes of pain when he worked exceptionally hard and had had a small hematemesis a few days before. Gastric series showed a normally functioning anastomosis without evidence of a recurrent ulcer. Our clinical diagnosis was marginal ulcer. The patient was symptom-free after two days of medical management. He was readmitted to the hospital June 20, 1945. He stated that he was able to work but had ulcer pain between meals. He had been taking a simple general diet divided in five small meals and had gained 20 pounds in weight since the previous admission. Gastric analysis was done and the results are seen in Table VIII. A gastric series showed a normally functioning anastomosis without evidence of a marginal ulcer. We again made a clinical diagnosis of marginal ulcer. The symptoms subsided after three days of hospitalization and medical treatment. The patient was advised to have another gastric resection, but he felt it wasn't necessary and returned home because he had "lots of work to do."

Comment.—In this case the removal of an insufficient amount of stomach is the cause of the recurrent ulcer. The patient should have a re-resection.

CASE 75.—E. T. (hospital No. 43-4308), a 45-year-old white man had had symptoms of ulcer for twelve years. In January, 1932, a free perforation was closed at another hospital. In June, 1932, a gastroenterostomy was performed elsewhere. On Dec. 16, 1942, a second free perforation was closed at a local hospital. The patient's chief complaints, on admission to our service, were pain and vomiting. Indication for resection was pain and a marginal ulcer. Operation was done on May 6, 1943. The duodenum revealed marked scarring. There was a jejunal ulcer opposite the stoma. The involved portions of the proximal duodenum, jejunum, and three-quarters of the stomach were resected. The continuity of the gastrointestinal tract was re-established by postcolic, terminolateral, oralis totalis gastrojejunostomy and en-y jejunojejunostomy. After operation a gastric analysis revealed the following free hydrochloric acid values: fasting, 37 degrees; fifteen minutes, 27 degrees; thirty minutes, 33 degrees; sixty minutes, 34 degrees. The patient had an uneventful course and was discharged on the fourteenth postoperative day. He returned in September, 1944, having gained 17 pounds in weight. He was eating five meals a day and was not restricting the diet as to type of food. His only complaint was a feeling of fullness immediately after meals. Gastric analysis was done and the results are seen in Table VIII. The patient was readmitted to the hospital June 14, 1945, because of pain, nausea, and vomiting of four months' duration. The pain had been severe for one week before admission, and five days before entrance he had a massive hematemesis. During the trip to the hospital he developed a left hemiplegia. Physical examination showed a left-sided paralysis and a marked pallor, and there were rigidity and tenderness in the epigastrium. The hemoglobin was 7.5 grams. The patient became weaker

and died four days after admission. Autopsy revealed gastrojejunal ulcer with perforation into the left transverse mesocolon and localized abscess, recent and old encephalomalacia with hemorrhage, and terminal pneumonia.

Comment.—We believe the reason for the recurrent ulcer in this patient is the same as that given for Case 50.

REPORT OF 121 ADDITIONAL GASTRIC RESECTIONS PERFORMED DURING 1944 AND 1945

During the past two years, 1944 and 1945, we have performed gastric resection in an additional 121 patients for peptic ulcer or its complications. Sufficient time has not elapsed for a detailed report to be of value, but a brief survey of these cases is of interest.

Forty-one, or 33.8 per cent, of these patients had had previous surgery for peptic ulcer. In thirty-one cases, or 21.98 per cent, the indication for resection was a severe complication of peptic ulcer or of previous inadequate surgical treatment. The indications for resections in these complicated cases were: marginal ulcer, seventeen; emergency resection for massive hemorrhage, seven; gastrojejunocolic fistula, six; acute perforation, one.

There were two postoperative deaths in the 121 patients, an immediate mortality of 1.6 per cent. We attribute the continued decrease in operative mortality to refinements in operative technique and careful attention to pre- and postoperative care. Two-thirds or more of the stomach was removed in a greater proportion of these patients than in the previous 100 patients.

We have been able to carry out follow-up examinations, including gastric analysis, in 92 per cent of the patients. Although the follow-up interval has been short, varying from three to twenty-seven months, no recurrent ulcers have developed.

There were two gastroenterostomies performed for peptic ulcer during the period in which these 121 gastric resections were done.

CONCLUSIONS

1. Our postoperative mortality has been reduced from 28 per cent in the first fifty gastric resections to 8 per cent in the second series of 100 consecutive resections. It was further reduced to 1.6 per cent in 121 consecutive resections done in 1944 and 1945. Over the five-year period, 1941 to 1945 inclusive, the mortality was 4.5 per cent.

2. Radical resection of the stomach per se did not increase the mortality rate.

3. We have extended our indications for resections in peptic ulcer, as evidenced by the increasing number of resections performed.

4. The symptom of bleeding occurred in a greater per cent than we had anticipated.

5. Chronic invalidism induced by peptic ulcer is more common than we had realized.

6. In this study "irremoveable" duodenal ulcers were rare.

7. Our rate of recurrent ulcer has been reduced from 14.7 per cent in the first fifty gastric resections to 4.3 per cent in the ninety-two survivors of the 100

resections studied in detail. There are no known recurrent ulcers in the 119 survivors who were resected in 1944 and 1945. For the five years, 1941 to 1945 inclusive, the recurrent ulcer rate was 1.89 per cent.

8. Recurrent ulcer was more frequent after conservative than after radical resection.

9. A relative achlorhydria is necessary to prevent recurrent ulcer.

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CONGENITAL HYPERTROPHIC PYLORIC STENOSIS

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DURING the past thirty years, certain principles have been evolved for the management of babies with congenital hypertrophic pyloric stenosis. As a result of their wide application, the mortality from this disease has fallen from the appalling figure of between 50 and 75 per cent to the point where one author[1] could state that he had operated on 134 consecutive patients without a fatality. While many clinicians are in general agreement as to the proper management of these cases, discussions of the relative merits of various treatment regimes continue to appear in the literature. Instances of mismanagement still occur with sufficient frequency to warrant continued emphasis on those practices which safeguard the welfare of these patients. Herein is presented a study of the 147 patients with congenital hypertrophic pyloric stenosis seen at the St. Louis Children's Hospital during the twelve-year period from 1933 through 1944. Earlier discussions from this clinic on the subject of pyloric stenosis are to be found in the papers of Hartmann,[2-4] McGahee,[5] and Clopton and Hartmann.[6]

In this series 81.7 per cent of the patients were males; 52.5 per cent of the male and 55.5 per cent of the female patients were first-born children. There were three instances in which two infants in the same family had pyloric stenosis. Of all the patients, 2.25 per cent were Negroes, whereas Negroes constituted 8 per cent of the total hospital population during the period of this study. The relative infrequency of the disease in the Negro can best be appreciated by the fact that during the eight years in which the Homer G. Phillips Hospital, a large Negro hospital in St. Louis, has been in existence, only one instance of congenital hypertrophic pyloric stenosis has been recorded at that institution.*

The frequency of complicating congenital anomalies in our series was low. One patient had a double harelip and cleft palate, two had congenital heart disease, and one was a mongoloid imbecile. Significant congenital anomalies were not evident in the other 143 patients.

DIAGNOSIS

Of the several important symptoms of pyloric stenosis, and the one which usually first attracts the physician's attention, *vomiting* is the most prominent. It begins with sufficient frequency in the first two weeks of life (Fig. 1), so that this disease should be included among those responsible for vomiting in

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*Courtesy of Dr. Dorothy Jones, Chief Pediatrician at Homer G. Phillips Hospital.

the newly born.[2] Although the vomiting is often of a mild nature for the first few days, it rapidly becomes more severe and more frequent, and relatively soon assumes typical characteristics in most cases. The vomitus is strongly acid and does not contain bile. The vomiting is projectile, occurs frequently, and tends to persist despite therapeutic methods ordinarily effective in the control of vomiting due to gastroenterospasm and improper feeding.

Most of the other symptoms of pyloric stenosis are a direct result of vomiting and, therefore, occur with considerable regularity. The infant usually passes only one or two small stools per day; these are small in volume and suggest true *constipation.* He seems to be always *hungry:* he continually sucks his fists and takes feedings very eagerly. Despite a variety of formulas and feeding methods, he fails to gain weight properly and, if the stenosis is not relieved, will soon begin to lose weight at an alarming rate. As though puzzled by his inconsiderate stomach, the baby often develops a characteristic *frown.*

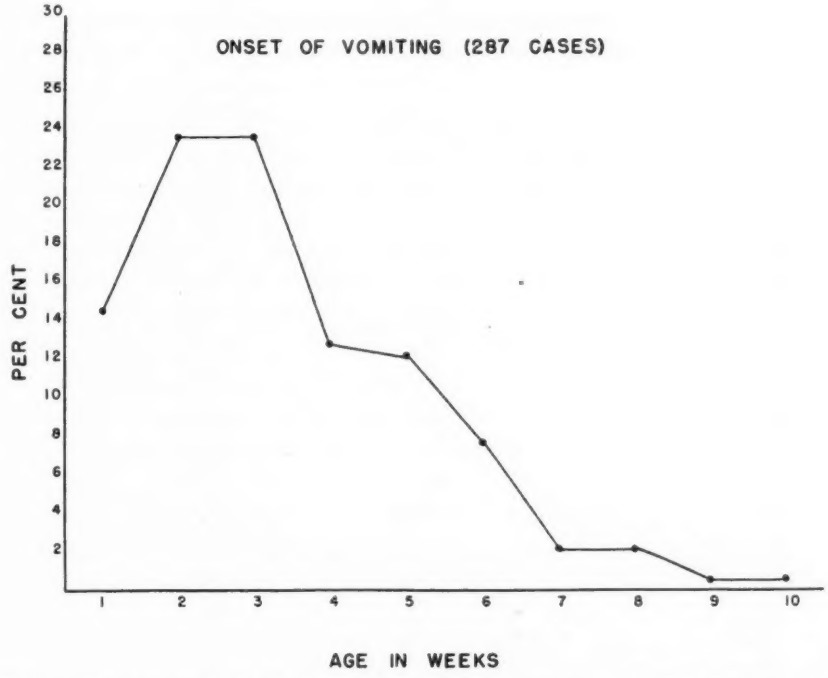

Fig. 1.—The age at which vomiting began in patients with pyloric stenosis seen at the St. Louis Children's Hospital from 1916 through 1944. The 140 patients reported by McGahee[5] are included.

As a consequence of vigorous peristaltic movements, the stomach wall becomes hypertrophied. Visible external evidence of this is seen in the *waves of gastric peristalsis,* which pass from left to right across the epigastrium. These become more prominent immediately after feeding and, with a proper tangential lighting effect, can be visualized in every case of pyloric stenosis. They can easily be distinguished from the waves of lower intestinal obstruction for, in the latter, waves are often visible in other parts of the abdomen

and have no constant pattern of movements. Because of thinning of the abdominal wall, gastric peristaltic waves are seen in many malnourished babies, however, and, therefore, cannot be considered pathognomonic of pyloric stenosis.

The hypertrophied pylorus can commonly be felt as an almond-shaped *tumor* just beneath the right lobe of the liver. A definite tumor could be palpated in 76 per cent of our patients. Several surgeons of wide experience have stated that under ideal conditions a tumor can be felt in every patient. Yet on more than one occasion in our series of cases, the hypertrophied pylorus was so situated, high under the liver edge, that it was impossible to feel it at time of operation through the abdominal incision. The presence of a tumor is pathognomonic of pyloric stenosis, but inability to feel it should not deter the physician from making the diagnosis and from instituting treatment.

Despite the regularity of vomiting in pyloric stenosis, *gastric retention* is a rather constant feature. This can be demonstrated by giving the baby a barium meal* and observing its course under the fluoroscope. Observations should be made every fifteen minutes during the first hour and then at half-hour intervals until three hours have elapsed following the test meal. In normal infants a small amount of the fed barium will be seen to pass into the small bowel within fifteen minutes, and the stomach will usually completely empty itself within the three-hour period. In contrast to this, the stomach of a baby with pyloric stenosis will be seen to be considerably enlarged and to exhibit *a delayed emptying time:* barium will not leave the stomach until thirty or sixty minutes have elapsed, and at the end of three hours usually about one-half of the fed barium will still be seen in the stomach. Barium studies were done on 115 of our patients, including all those in whom a pyloric tumor was not felt. Only five patients failed to show a delayed emptying time of the stomach, and in one of these the emptying time was typically delayed when the procedure was repeated four days later. It should be remembered that a delayed emptying time will be seen occasionally in infants ill from other causes and that barium studies should be used only to confirm the diagnosis of pyloric stenosis.

The persistent vomiting produces other important effects. Since the stomach of the baby suffering from pyloric stenosis continues to secrete gastric juice of normal acidity, great quantities of hydrochloric acid are lost. This leads readily to depreciation of the blood chlorides which in turn results in a compensatory increase in bicarbonate content. The wastage of ingested food through vomiting also allows the body to become depleted of protein and of water. Three important results occur: *alkalosis, malnutrition,* and *dehydration.* The intensity of each of these phenomena varies directly with the length of time the disease has been allowed to progress.

Alkalosis manifests itself clinically in the form of *irregular shallow respirations* and frequent periods of apnea. *Tetany* may occur. Because of the fact that these patients are very young infants, tetany will usually be manifested, not by carpopedal spasm, but by generalized muscular rigidity and occasionally by a convulsion. The presence of alkalosis may be confirmed only by

*One teaspoon of barium sulfate to one ounce of milk or formula.

making an analysis of the blood serum for its carbon dioxide content, which is largely a measure of bicarbonate. In metabolic alkalosis this will be elevated to a varying degree from the normal value (for small infants) of 50 to 60 volumes per cent. Analysis of the urine for its chloride content may be of help, for the chlorides (by the silver nitrate test) are usually absent from the urine of patients with pyloric stenosis. As Hartmann and Smyth[7] pointed out, the pH of the urine in this disease does not always reflect the bicarbonate content of the blood but depends rather upon the total osmolar concentration. If the sum of the bicarbonate and chloride contents of the blood serum exceeds that which obtains in the blood of a normal individual, sodium bicarbonate will be excreted in the urine, and the urine will then be alkaline. Due to the fact, however, that the vomitus of patients with pyloric stenosis contains an appreciable amount of sodium chloride in addition to hydrochloric acid, a considerable loss of base as well as chloride may occur, resulting in a reduction of the sum of the bicarbonate and chloride contents of the blood serum below the normal value. Under such circumstances the body tends to conserve base by excreting an acid urine. Obviously, then, the urinary pH is not an accurate indication of the presence or absence of alkalosis in patients with pyloric stenosis.

To illustrate the frequency and degree with which alkalosis occurred in this series, Table I, which correlates the blood chemical findings of our patients on admission to the hospital with the duration of vomiting, has been prepared.

TABLE I

	DURATION OF VOMITING IN DAYS				
	1 TO 7	8 TO 14	15 TO 21	22 TO 28	OVER 28
Serum CO_2 Content (Vol. %)					
Less than 50	0	0	3	2	1
50 to 70	12	12	4	1	9
70 to 90	3	14	12	2	6
90 to 110	0	4	3	1	11
Over 110	0	0	2	3	4
Serum Chloride as NaCl (Mg. %)					
550 to 650	2	10	6	2	5
450 to 550	6	10	8	1	5
350 to 450	1	4	4	5	10
250 to 350			2		2
Below 250				1	2

There is a rough correlation between the duration of vomiting and both the increase in bicarbonate and the reduction in chloride content of the blood serum. In prolonged cases, however, this relationship may no longer exist, for starvation and dehydration may become sufficiently marked, and anhydremia may sufficiently impair renal function, so that complicating factors enter the picture. For example, a great extension of bicarbonate may be considerably checked through the accumulation of organic acids, the retention of sulfate and phosphate, and an increase in protein. Likewise, a low chloride value may be elevated by reduction in the water content of the blood serum through dehydration. This phenomenon is illustrated in the fifth column

of Table I, in which it can be seen that a number of the values for bicarbonate fall in the normal or slightly elevated groups and that a considerable number of the chloride values are in the normal or moderately depressed groups.

Some indication of the degree of dehydration in these patients and the amount of attendant renal insufficiency is given by the values for serum nonprotein nitrogen obtained on admission to the hospital. Of the thirty-six patients for whom such values were recorded (which includes most of the severe cases) twenty had elevated nonprotein nitrogen values; ten of these were in the range between 35 and 50 mg. per cent; nine were between 50 and 100 mg. per cent, and one was 112 mg. per cent. The azotemia promptly disappeared upon relief of dehydration and resumption of adequate urinary flow.

The continued occurrence of vomiting, especially if it is projectile in nature, is frequently a factor in the production of otitis media in young infants. In this series, 13 per cent of the patients had otitis media on admission to the hospital, and 10 per cent subsequently developed it during their postoperative convalescence.

Other complicating infections present in our patients on admission were one instance of pyelitis, three of acute pharyngitis, four of generalized upper respiratory infection, and one of suppurative cervical adenitis. Complications met with during the postoperative period were one instance of pyelitis and colon bacillus sepsis, three of bronchopneumonia, one of bronchitis, two of pertussis, and one of exanthem subitum.

TREATMENT

The analysis by McGahee[5] of those cases of pyloric stenosis seen at this clinic from 1916 through 1932 established the superiority of the surgical over the medical treatment of this disease. All of the patients in this present series were subjected to operation, with the exception of four patients who died before they could be made ready. The only occasion in which a medical regime of therapy seems at all feasible is in those patients who are first seen at the age of 3 months or more and whose nutritional status is sufficiently good to presuppose a relatively mild degree of stenosis of the pylorus.

Preoperative Care.—Preoperative therapy has the following aims: (1) the restoration of normal electrolyte and fluid balance, (2) the amelioration of malnutrition, and (3) the control of complicating infections. We should like to emphasize that these considerations are of the utmost importance and that they should be satisfied, in so far as is possible, before any surgical procedure is undertaken. Congenital hypertrophic pyloric stenosis is not a surgical emergency, and far more harm may come from operating hurriedly upon an ill-prepared patient than by waiting two or three days until conditions are optimal. In instances where the diagnosis is made early in life, the baby's condition may be such that almost no preoperative therapy is required or at the most one or two subcutaneous infusions of Ringer's or saline solution. However, in a large majority of our patients this was not the case: less than one-half of our patients were admitted to the hospital within two weeks of the

onset of symptoms, and fully one-fifth of them were not brought to us until from one to two months had elapsed. In some of the more severe cases the patients required from four to six days of preparation before they were considered fit for operation.

The first two aims of preoperative therapy—the restoration of normal electrolyte and fluid balance and the amelioration of malnutrition—involve the following considerations: (1) the correction of alkalosis, (2) the correction of hypochloridemia, (3) the abolition of dehydration, (4) the relief of hypoproteinemia and anemia, (5) the augmentation of liver glycogen reserves, and (6) the minimization of starvation during the preoperative period. Although small oral feedings, offered at frequent intervals, are given during the preoperative period, it is obvious that all of these aims must be met via the parenteral route. They can be accomplished most easily and simply in the following ways:

(1) The repeated intravenous administration of 10 per cent dextrose in saline or Ringer's solution in amounts of 20 c.c. per kilogram of body weight. If this procedure must be repeated frequently, 10 per cent dextrose in water should occasionally be substituted in order to minimize the occurrence of edema.

(2) The repeated subcutaneous or intraperitoneal infusion of Ringer's solution in amounts averaging 100 c.c. per kilogram of body weight per day.

These procedures will relieve dehydration, restore glycogen reserves in the liver, reduce hypochloridemia, and establish diuresis so that the kidney through its wonderful capacity of selective reabsorption can excrete sufficient sodium bicarbonate to attenuate the alkalosis. Once the patient has been well hydrated, the following steps should be taken:

(3) The transfusion of whole citrated blood or of plasma, according to the blood hemoglobin value, in amounts of 20 c.c. per kilogram of body weight. Equivalent amounts of concentrated serum albumin may be substituted for blood plasma.

(4) The subcutaneous administration of a solution composed of 3.3 per cent dextrose and 3.3 per cent Amigen in one-third Ringer's solution* in amounts approximating 100 c.c. per kilogram of body weight per day.

Thus hypoproteinemia is corrected, calories provided, blood volume restored to normal, and kidney function stimulated to reduce further the alkalosis. This regime is continued until the blood serum carbon dioxide content, chloride, and protein values are approximately within normal limits and will suffice to prepare adequately for operation the great majority of these patients. However, in those patients in whom fluid and electrolyte changes are severe and starvation marked, several other measures may be necessary. The correction of a severe alkalosis, which may result in tetany, convulsions, and such reduction in respiratory excursions that death is imminent, often will require the following additional measures:

(5) The inhalation of 30 per cent carbon dioxide in oxygen. By increasing the carbon dioxide tension of the blood, the blood pH will be lowered

*"D-A-R" solution; this can be made up easily by mixing equal parts of 10 per cent dextrose, 10 per cent Amigen, and ordinary Ringer's solutions.

temporarily and breathing stimulated. Continuous oxygen therapy is often of great help.

(6) The intravenous injection of 5 per cent calcium chloride in amounts of 0.5 c.c. per kilogram of body weight. An excess of calcium is thus made available to augment that portion of the blood calcium rendered non-ionizable because of the alkalosis, and an acidifying action is produced by virtue of the fact that the calcium is excreted to a large extent through the bowel, thus leaving the chloride ion available for combination with base from bicarbonate in the blood.

(7) The intravenous injection of hydrochloric acid, as reported by Hartmann.[3, 4] The response to hydrochloric acid is prompt, but it has the disadvantage of being extremely irritating to the blood vessel walls and must be given with the greatest of care. Because of its powerful acidifying action, it will quickly lower the blood pH, but this same attribute makes it difficult to inject sufficient quantities to elevate adequately the serum chloride. Hydrochloric acid has been given intravenously to four patients in this series. In two of them, respiratory failure occurred during the immediate postoperative period; the response to hydrochloric acid was dramatic and was definitely a lifesaving measure. In another it successfully relieved generalized convulsions and spasticity which had not been influenced by carbon dioxide inhalations or the intravenous administration of calcium chloride. The fourth patient had only slight improvement in symptoms from the use of hydrochloric acid because of the presence of a concomitant severe hypoglycemia. Following the intravenous administration of glucose, his respirations rapidly improved.

The solution of hydrochloric acid, as we have employed it, has been made up in various ways. In one patient, 1 c.c. of concentrated hydrochloric acid was diluted to 100 c.c. with Ringer's solution, and 20 c.c. of this mixture were given. In another, 3 c.c. of concentrated acid were mixed with 60 c.c. of Ringer's solution and 20 c.c. of the resultant mixture used. The third patient was given 170 c.c. of one-sixth molar hydrochloric acid in normal saline solution in three divided doses. In the fourth patient 40 c.c. of one-tenth normal hydrochloric acid were mixed with 70 c.c. of normal saline and the entire solution given. When these amounts are calculated on the basis of the strength of the solution used per kilogram of body weight for these respective patients, they are: 10 c.c. per kilogram of one-tenth normal acid, 6 c.c. per kilogram of one-half normal acid, 60 c.c. per kilogram of one-sixth normal acid, and 37 c.c. per kilogram of one-seventeenth normal acid. Because of the obvious dangers of administering hydrochloric acid intravenously, it should be used only as an emergency measure in instances of severe alkalosis.

The third preoperative objective, that of control of complicating infections, must be achieved, for otherwise nutrition during both the pre- and postoperative periods may be greatly hampered. Further, since postoperative vomiting or diarrhea is occasionally a problem, anything which might possibly contribute to their occurrence should be corrected. The judicious use of the sulfonamide drugs and of penicillin should suffice to control most such infections.

Anesthesia and Operative Procedure.—A Fredet-Rammstedt pyloroplasty was performed on 143 patients in this series. Since twenty-four different surgeons, including both visiting staff and house officers, participated in the series, there has been some variance in preoperative medication, anesthesia, and finer points of operative technique. Since the technical details of this operation are now well known, we propose to discuss only those general features of special importance.

We believe that preoperative medication is not necessary, and our experience indicates that premedication with morphine may actually be dangerous. In eight of the eighty-three patients who received $\frac{1}{60}$ to $\frac{1}{120}$ gr. of morphine and were operated upon under local anesthesia, the immediate postoperative course was complicated by marked respiratory depression and generalized cyanosis. This complication has not been encountered in a single one of the sixty patients operated upon without premedication, and accordingly, we feel justified in concluding that the morphine was a major factor in the cause of the respiratory depression. Further, we prefer not to use atropine, which often causes an annoying flush and elevation in temperature.

We are in full agreement with Ladd and Gross[8] that drop ether is the anesthetic of choice, and we have experienced no complications attributable to ether anesthesia in this series. So little ether is required for the satisfactory quieting of these infants that in every instance they have awakened before leaving the operating room. There seems to be little advantage in employing a local anesthetic, since in an appreciable percentage of cases it is necessary to use supplementary ether anesthesia when the peritoneum is opened or during closure of the wound because of annoying and dangerous movements of the patient. Moreover, the only two instances of delayed wound healing in our 143 patients operated upon occurred in those in whom a local anesthetic (novocain) was used.

Before the abdominal wound is closed, the operator should assure himself that the mucosa of the duodenum is intact. In our series the duodenum was inadvertently opened in twelve patients. In eleven of these the perforation was recognized at operation and closed with interrupted fine silk or catgut sutures; as a consequence, their postoperative courses were uneventful. In the other case the opening was not discovered, and the patient succumbed to a generalized peritonitis.

Postoperative Care.—The infant should be offered food within a few hours after the effects of the anesthetic have worn off, so that the earliest possible start is made toward regaining a normal nutritional status. The food should provide sufficient calories yet require a minimal amount of digestive activity and be absorbed easily through the intestinal wall. Because the stomach is actually hypertrophied as well as dilated, gastric motility may still be impaired despite the presence of an adequate pyloric lumen. Consequently, the food should be of the type which passes readily from the stomach into the small intestine. One of the most serious complications during the postoperative period is that of diarrhea, the occurrence of which can be minimized by the use of an acid feeding.[2]

The following feeding schedule meets these requirements nicely. About two hours postoperatively the infant is offered 15 c.c. of a mixture composed of equal parts of 10 per cent dextrose, 10 per cent amigen, and buffer water* (D-A-B). Two hours later he is offered alternate feedings at two-hour intervals of 15 c.c. of D-A-B and 15 c.c. of a formula composed of one part evaporated milk, one part water, and one part of a 1 per cent lactic acid-15 per cent Karo mixture. The next day the amounts are increased to 30 c.c. and the next to 60 c.c. per feeding. On the fourth postoperative day, D-A-B is omitted, and the milk formula is offered every three hours in 90 c.c. amounts. Further feedings are adjusted individually to the patient, but by the tenth postoperative day the infant is usually taking 120 c.c. of a fairly concentrated acidified evaporated milk formula every four hours. If breast milk is available, it may be substituted for the evaporated milk formula in this feeding schedule and the baby put to breast on the second or third postoperative day.

If we take as an example a 7-week-old infant, whose ideal weight would be 4,500 grams, the amounts of calories, protein, carbohydrate, and fluid as shown in Table II would be supplied by this feeding regime.

TABLE II

POSTOPERATIVE DAY	CALORIES PER KG.	PROTEIN (GM. PER KG.)	CARBOHYDRATE (GM. PER KG.)	TOTAL FLUID (C.C. PER KG.)
1	18.5	1.1	2.3	40
2	37.0	2.2	4.6	80
3	74.0	4.4	9.2	160
4	106.0	3.7	13.3	160

It is obvious that it is only the first two postoperative days in which supplementary parenteral feeding and fluid in the form of Ringer's or dextrose-amigen-Ringer's solutions will be needed.

DISCUSSION

Eight of the 147 patients in this series died, which is a mortality rate of 5.4 per cent for the twelve-year period covered by this study. Four patients died prior to operation, so that the mortality for the group of patients operated upon is 2.8 per cent.

Three patients died from the effects of severe alkalosis and malnutrition. At the time they were admitted to the hospital they presented the picture of marked malnutrition and dehydration with subnormal temperature, cyanotic color, and irregular breathing. They weighed from 800 to 1,500 grams less than their respective birth weights. The serum carbon dioxide contents were above 100 volumes per cent and the serum chlorides below 325 mg. per cent in each. Despite vigorous attempts to correct these conditions, they all succumbed within three days. Surgical exploration in these cases would have been most foolhardy, for any operative procedure would certainly have hastened the deaths. An autopsy was done on two of the patients and, except for the typical hypertrophied pyloric muscle, revealed only mild terminal bronchopneumonia.

*Buffer water: a mixture of 1 per cent lactic acid and 0.5 per cent sodium-r-lactate.

The importance of proper control of the biochemical factors in this disease is further amplified by our experiences with two patients in whom alkalosis and hypochloridemia had not been properly corrected prior to operation. Local anesthesia and morphine premedication were employed in each, and both of them suffered such marked respiratory depression postoperatively that without the prompt intravenous administration of hydrochloric acid, death would have occurred. The extent of the biochemical change in patients with pyloric stenosis is also of some prognostic significance, for of the five patients in this series whose serum chlorides were below 300 mg. per cent on admission to the hospital, three died before they could be prepared for operation.

The dangerous potentialities of atropine are evident from a study of the fourth fatal case. This baby was in excellent general condition at the time of admission to the hospital, and because the symptoms had been mild, it was decided to employ a regime of medical therapy. After three days of therapy with atropine and thickened feedings, he developed massive gastric dilatation which, though relieved by gastric lavage, recurred the following day and was followed by gastric perforation, peritonitis, and death. Such an experience serves to emphasize a cardinal rule in the therapy of pyloric stenosis: never postpone surgical treatment beyond the period needed to prepare the patient for operation once the diagnosis has been definitely established. Despite our firm conviction that pyloroplasty is the treatment of choice, we have on several occasions employed one of the various schemes of medical therapy which are advocated from time to time. The result has always been the same: operation was eventually required, and frequently the postoperative convalescence has been longer than usual because of the occurrence of some intercurrent infection or diarrhea.

Two patients died of complicating infections during the postoperative convalescence. One, seen in the period before the sulfonamide drugs were available, had an otitis media on admission to the hospital and subsequently developed a bronchopneumonia and expired on the ninth postoperative day. The other developed a colon bacillus pyelitis and sepsis and, despite the use of sulfanilamide, expired on the twentieth postoperative day. Now that more powerful sulfonamide drugs and penicillin are available, the number of fatalities from concurrent infections should be considerably reduced. Such therapy should be employed promptly in all instances of concurrent infections in these patients, however trivial such infections may appear at the onset.

The seventh fatality represents the only instance in this series in which a duodenal perforation was overlooked at the time of operation, and death came as a result of generalized peritonitis. In the eighth fatal case, two Fredet-Rammstedt pyloroplasties done three weeks apart failed to relieve the patient's symptoms, nor did a posterior gastrojejunostomy done three days later do so. Despite these procedures and vigorous supportive therapy, the baby became progressively worse, blood appeared in the vomitus, convulsions and cyanosis developed, and death occurred four days after the last operation. An autopsy revealed that both the pyloric and gastroenterostomy lumina were

patent and that there was some bronchopneumonia in all lobes of the lungs. Examination of the spinal fluid during life was normal, but unfortunately permission was not granted to study the brain at autopsy.

SUMMARY

One hundred forty-seven consecutive cases of congenital hypertrophic pyloric stenosis seen at the St. Louis Children's Hospital during the past twelve years are reviewed.

The important diagnostic features of the condition are discussed and the value of proper preoperative therapy emphasized, particularly the correction of disturbances in acid-base and fluid balance, the amelioration of malnutrition, and the control of complicating infections. The use of amigen in the therapeutic scheme is outlined.

Early surgical treatment using drop ether anesthesia is advised. Morphine as a premedication is contraindicated.

The cause of death in the four preoperative and four postoperative cases is discussed briefly.

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LESIONS OF THE AMPULLA OF VATER

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THIS report will concern itself with four different lesions of the ampulla of Vater which have been observed in the past three years. The conditions are (1) cystic dilatation of the common bile duct, (2) benign papilloma of the ampulla, (3) adenocarcinoma of the ampulla, and (4) ulcer of the duodenum affecting the ampulla. A description of each of the conditions listed here will be made in the order stated. Following a short historical résumé of the conditions in question, a specific case representing each of the lesions named will be discussed.

CYSTIC DILATATION OF THE COMMON BILE DUCT

Cystic dilatation of the common bile duct is of such rarity as to make it advisable to report all such cases. It is well to recognize that only at operation can such conditions be regularly differentiated from the more frequent, less hopeful malignant neoplasms.

From the present number of approximately 250 such cases, the following brief facts are known. The condition appears almost entirely in childhood or young adulthood, and is most frequent in females below the age of 25 years. Rolleston[20] suggested the causes of cystic dilatation were (a) idiopathic—that is, no obvious obstructions, and considered due to a primary inherited weakness of the wall of the duct; (b) obstruction at the distal end of the common duct as by congenital stricture, trauma, stones or surgery, infections such as syphilis, typhoid, and a more heterogenous group of bacteria from the intestine. The condition is accompanied by symptoms[18, 23] and findings, as recurrent jaundice and occasionally paroxysmal pain. Rolleston[20] and Jelks[11] described two cases of great dilatation of the common duct producing gigantic thin-walled cysts. These were considered idiopathic in nature. In 1943, Brooks and Weinstein[3] described a large, multilocular cyst in a duodenal diverticulum producing symptoms of acute cholecystitis. The cyst was found on section to be lined with duodenal rather than choledochous mucosa.

CASE 1 (Hosp. No. 412248).—A 68-year-old Scottish woman had been in the Presbyterian Hospital twelve years previously for arthritis, migraine, and intercostal neuralgia. On this first admission, she had given a history of occasional mild right upper quadrant distress. The history of her presenting complaints were: Since August, 1943, she noted a continuous darkening of the urine without blood, and the stools were of clay color. She lost her appetite and began to lose weight. In September, 1943, she began to have right upper quadrant pain, radiating to the right subscapular region and across anteriorly to the left upper quadrant. The pain was intensified by fats and lasted minutes to hours. Nausea was present in the absence of pain. There was no emesis. At no time had there been fever or chills. Other than these, the systemic inventory was relatively negative. Physical examination revealed the following pertinent facts: The patient was extremely jaundiced, dehydrated,

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and weighed 150 pounds. Blood pressure was slightly elevated. Respirations and pulse were normal. Temperature was 98.8° F. The heart findings were consistent with the elevated pressure. The liver was palpable 8 cm. below the right costal margin with the question of a small, irregular, hard mass on its tender, free border. The kidneys and spleen were not palpable. There was no rigidity or scars.

The differential diagnosis at this time was regurgitation, jaundice of an obstructive type due to malignant neoplasm of the common duct or of the pancreatic head, metastatic carcinoma of the liver, and arteriosclerotic, mild hypertensive cardiovascular disease.

Treatment instituted was analgesics, vitamins K and C parenterally, high multivitamin, high carbohydrate, low fat, low protein diet, and proposed surgical exploration.

Preoperatively, the positive laboratory findings were soft, formed clay-colored stools and urine 2 plus albumin in which bile was present. The serology was negative. There was slight anemia. Icteric index was 102. Van den Bergh test was direct, immediate, and positive. Prothrombin level was 100 per cent. Roentgenography demonstrated a nonfilling gall bladder, without stones (Fig. 1).

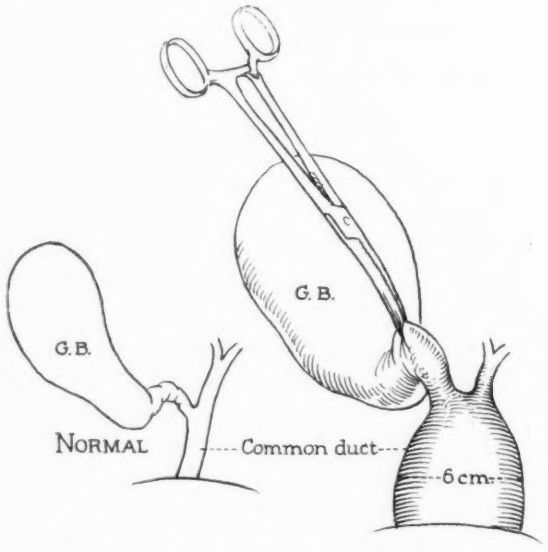

Fig. 1.—Left, normal; right, enormously enlarged gall bladder, cystic and common ducts.

At operation the liver was greatly enlarged, bronze-copper in color. The gall bladder was markedly distended, without stones. The common duct (see Fig. 1) was very large, 4 to 6 cm. in diameter. The walls of the duct were only moderately thickened. The gall bladder was explored and aspirated a very thick, viscid, black bile. The common duct was opened and thoroughly explored without evidence of obstruction. There was a firm nodule felt at the head of the pancreas about 0.5 to 1.0 cm. in diameter which did not seem to encroach on the common duct. The duodenum was opened, the ampulla of Vater, identified, and a catheter was inserted into the common duct. No obstruction was found. The gall bladder was anastomosed to the pyloric end of the stomach. The common duct and duodenum were closed. A drain was placed in the right kidney fossa. The peritoneum and abdominal wall were closed in the usual manner.

Without biopsy, a tentative diagnosis was made of malignancy of the head of the pancreas and congenital enlargement of the common duct.

Fourteen days after operation, the stools and urine were normal. Icteric index was 23.

The patient left the hospital ambulatory on the forty-first postoperative day.

The patient was observed ambulatory from April 12, 1944, to Dec. 21, 1945. During this period of observation, there was a gradual increase of jaundice, constipation, and upper

abdominal pain radiating to the left shoulder. Hemoglobin was stabilized at 65 per cent. In December, 1945, she was readmitted to the hospital with a marked accentuation of transepigastric pain, formed light yellow to clay-colored stools, an inability to eat fatty foods, a generalized pruritis, and bile-stained urine. A nodular liver with a tender caudate lobe was palpable below the right costal margin. Hemoglobin was 62 per cent; red blood cells, 3.72; icteric index, 76; prothrombin, 75 per cent; Van den Bergh immediate, direct, positive. Two weeks later the icteric index was 100 and the Hangar test negative at the end of forty-eight hours. Two weeks after this icteric index was 157, at which time the patient was discharged from the hospital with poor prognosis. The diagnosis at this time was neoplasm at the head of the pancreas with metastasis to the liver and obstruction of the bile ducts.

Summary.—The case presented here has certain interesting relationships with and contradictions to the facts mentioned in the historical résumé, such as the advanced age of the patient and the apparent idiopathic nature of the dilatation in the absence of a demonstrable obstruction unless one considers that the tumor nodule at the head of the pancreas produced the obstruction.

In addition, this patient had symptoms which should be differentiated from stones in the duct and carcinomas and papillomas of the ampulla; therefore, an exploration of the ampulla is indicated in any case of bile duct obstruction.

BENIGN PAPILLOMAS OF THE AMPULLA OF VATER

Because the greater number of the reports on tumors of the ampulla of Vater has been concerned with malignancies primarily in this region,[2, 7, 9, 13-15, 19, 20, 22] one comes to the conclusion that the majority of tumors of the ampulla are malignant; however, a few cases of benign ampullary tumors have been observed.[5] The importance of these benign lesions is obvious inasmuch as their differentiation from early malignant growths is not possible except at the time of surgical exploration. The further importance of such tumors is to be emphasized when one realizes that 70 per cent[19] of the also rare[16] carcinomas of the duodenum are at the ampulla.

The first known recorder of these benign tumors was Bouisson,[5] who in 1843 described what was apparently a lipoma of the ampulla in a cadaver. Since this time, there have been reported approximately seventy clinical cases.

In 1939 Christopher[6] listed forty-one cases. In order of frequency, there were papillomas, adenomas, lipomas, fibromas, neuromas, granulomas, melanoma, and carcinoid. Only six of these cases were known definitely to involve the ampulla.

Up to October, 1936, there had been only twenty-five cases of benign tumors of the bile ducts found by the Mayo Clinic during 34,000 operations on the biliary passages.

In 1937 Brunschwig[4] successfully operated on a carcinoid of the ampullary region.

Papilloma as the Precursor to Carcinoma of the Ampulla of Vater.—Accepted by some is the belief of Rolleston[20] that primary carcinomas of the region of the Ampulla of Vater start as benign papillomas. This is because of the similarity[6] of the gross and microscopic appearance of benign tumors to the low-grade papillary carcinomas. MacCarty[13] raised the question as to the possi-

bility of ulceration of the periampullar duodenum being the precursor of such malignancies. He reported three such ulcerocarcinomatous cases in 1910. The statement by Mayo-Robson[17] that calculi in the common duct are causes of papilloma or carcinoma is a debatable one.

The Nature of the Papilloma About the Ampulla of Vater.—Most of the papillomas are of a columnar epithelial type and not of glandular formation. This is in contradistinction to the adeno type of formation of the carcinomas. The tumors are usually very small. They may be cystic or solid[7] and consist[2] usually of small hard white masses, often readily mistaken for an impacted calculus or a carcinoma.

Common Symptoms and Findings of Tumors of the Ampulla of Vater.—The most common symptoms and findings are those of painless jaundice, generalized pruritis, weight loss (due, according to Hunt,[10] to retention of bile and loss of external pancreatic secretion), hepatomegaly, fever, and diarrhea.

CASE 2 (Hosp. No. 410117).—A 49-year-old Italian man, up to five months previous to admission, had been in perfectly good health. He then noted a yellowness of the sclera, consulted a doctor, and, although gall bladder studies showed absence of stones, but no visualization, surgical treatment was not advised. The scleral jaundice persisted one month, then disappeared, but recurred one month before admission, persisting until after operation. During the last icteric period, a generalized itching, becoming progressively worse, occurred. In the four months previous to admission, he experienced anorexia and a twenty-five pound weight loss. Stools had been at times acholic, at other times normal in color, but pasty in consistency. He had not noted the urine color. At no time had there been any pain, fever, or chills.

Past history and systemic inventory were negative other than for the facts given.

Physical examination revealed an Italian man, deeply jaundiced. Temperature was 98.8° F.; respirations, pulse, and blood pressure were normal; the abdomen was slightly rigid and distended; a firm, movable mass was palpable 6 cm. below the right costal border. It was smooth and not tender, with a sharp margin. The spleen and kidneys were not palpable. There was no rectal abnormality.

A tentative differential diagnosis was (a) carcinoma of the head of the pancreas, involving the ampulla of Vater, (b) toxic hepatitis, (c) biliary cirrhosis, (d) primary hetatic malignancy, or (e) metastatic hepatic malignancy.

Treatment advised was high vitamin, high carbohydrate, low fat, low protein diet; vitamins C and K parenterally; surgical exploration.

Before operation the pertinent laboratory findings were formed clay-colored stools, positive for chemical blood. Gross fat, bile, meat fibers, and parasites were absent. Urine was dark but otherwise normal. Serology was negative. There was slight hyperchromic anemia. Leucocyte count was normal. Icteric index was 67; van den Bergh was direct, immediate, positive. Prothrombin was 100 per cent. Hangar's test was negative at twenty-four hours, 4-plus at forty-eight hours. Roentgenography showed a nonfilling gall bladder without stones.

At operation the gall bladder was greatly distended to ten times its normal size. There were glands along the gastrohepatic omentum. Aspiration produced no stones from the gall bladder, which was explored. The head of the pancreas was only slightly thickened. When the duodenum was opened, a papillomatous mass protruded through the ampulla. Immediate frozen microscopic section of the curetted tumor was reported as benign as was an adjacent gland in the hepatic omentum. The gall bladder was anastomosed to the opening of the duodenum. Due to the patient's severe jaundice, resection of the ampulla at this time was deemed unwise. The incision was closed in layers after placing a drain in the right kidney fossa. The patient was returned to his room in good condition. The stools and urine

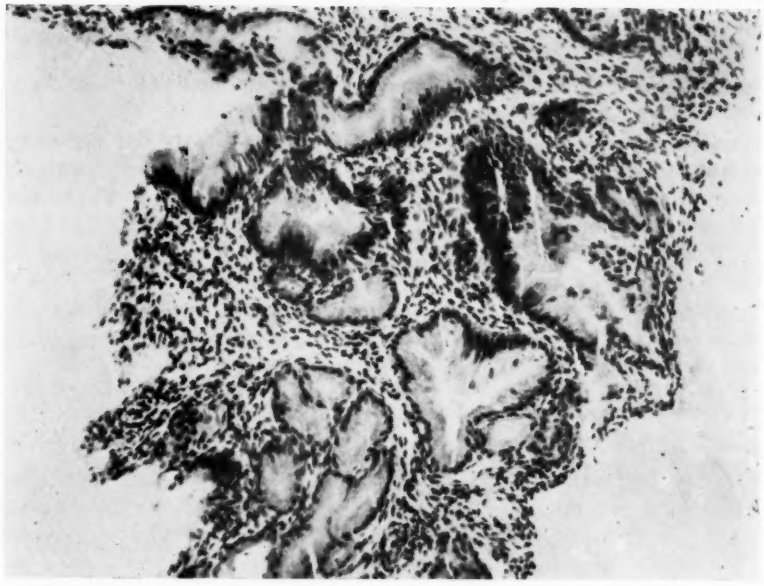

Fig. 2.—An overgrowth of glandular epithelium with slightly increased staining power. This is a portion of a papillary piece of tissue removed from the lining of the duodenum.

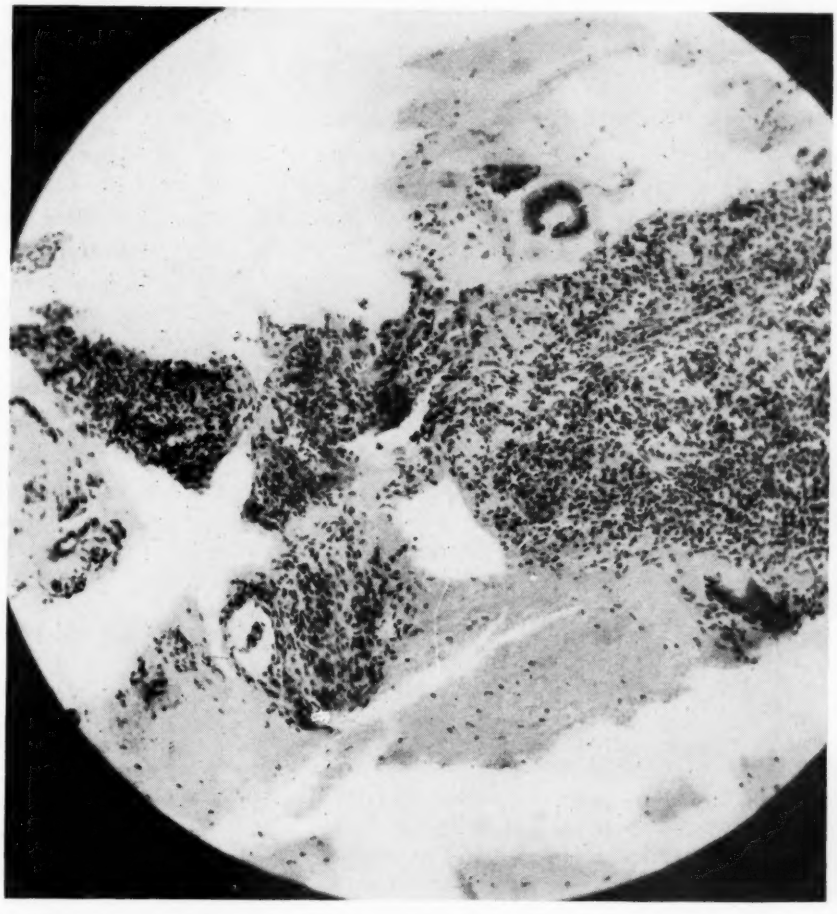

Fig. 3.—Biopsy specimen showing a benign overgrowth of glandular epithelium over a fibrous core.

became normal in a few days. The patient left the hospital ambulatory on the twenty-third postoperative day (Figs. 2 and 3).

The patient was seen seven months after the operation. He felt fine and had gained twenty-two pounds with no recurrence of jaundice or itching. The stools and urine remained normal. Icteric index was 12 and other blood chemistry tests were within normal limits. Gall bladder roentgenography at this time demonstrated a deformed duodenal cap and some irregularity of the second portion of the duodenum. There was no evidence of regurgitation of barium from the duodenum into the gall bladder.

The patient was seen two years later in excellent health, with satisfactory weight gain. X-ray examination at this time showed no retrograde filling of the bile tracts. The conclusion was that the lesion was benign.

Summary.—In view of the previous discussion as to the possibility of benign lesions being the precursor of malignancies of this region, the question might be raised as to whether or not it might have been advisable to remove the ampulla and reimplant the common duct and duct of Wirsung into the lower duodenum.

CARCINOMA OF THE AMPULLA OF VATER

Brunschwig[5] stated that Avezou[1] offered one of the earliest descriptions of carcinoma of the ampulla of Vater in 1875. He also referred to a report of such growths previously made by Ferreol and Lutton in 1859. As previously mentioned, adenocarcinomas of the region of the ampulla of Vater are the most common of this area. However, Brunschwig[5] stated that ampullar carcinoma is relatively uncommon. According to Lieber, Stewart, and Lund,[12] there were 14 cases among 22,152 necropsies at the Philadelphia General Hospital between 1920 and 1936, and 4 cases at the Jefferson Hospital, Philadelphia, among 4,154 necropsies. This presents an incidence of 1.13 per cent of all carcinomas and 0.09 per cent of all autopsies. Roscher[21] noted 5 cases of ampullar carcinoma among 8,724 autopsies performed in Oslo between 1900 and 1936. On gross examination in situ, these may readily be mistaken for small calculi or benign neoplasms. Therefore, as stated before, these must be most closely scrutinized and biopsy made if at all possible. Radical resection for this type of tumor was first performed in 1899 by Halstedt.[8] Since this time many variations in the technique have been developed. For a review of such techniques one may refer to Brunschwig.[5]

CASE 3 (Hosp. No. 416331).—A 65-year-old Polish man, a laborer, entered the hospital Feb. 9, 1944, complaining of one year's duration of chronic cough, for which no cause could be found. For seven months he had had an increasing generalized painless jaundice and a loss of ten pounds in weight. For two weeks stools had been loose and gray. At no time had there been anorexia, fever, chills, or itching.

The pertinent findings were generalized jaundiced skin and a slightly irregular, firm, movable mass extending 7 cm. below the right costal margins and 10 cm. below the middle third of the left costal border. There were small external hemorrhoids. The stool was acholic and pasty, with 2 plus occult blood. The urine contained urobilin. There was a mild secondary anemia. Roentgenography demonstrated a nonfilling gall bladder without stones.

After the usual preoperative preparations, the abdomen was opened. The liver was cirrhotic, atrophic, and about one-half its normal size. A nodule which felt like a soft stone, but proved to be a neoplasm, was palpated 3 cm. above the ampulla in the duodenal lumen. The common duct was explored. There was some gravel but no stones. A catheter would not pass into the duodenum through the common duct. The duodenum was opened. The

ampulla was involved in a carcinomatous growth which was resected. Because of the absence of any bile, due to obstructoin, the gall bladder was anastomosed to the stomach. The openings in the common duct and duodenum were closed. The patient survived seventy-two hours after the operation, death being due to a generalized peritonitis and hypostatic pneumonia (Fig. 4).

Summary.—In this case certain interesting observations are of note, namely, (a) the similarity of symptoms and findings with those of the two preceding cases, (b) the presence of the colorless fluid in the gall bladder, and (c) the cirrhotic nature of the liver.

The prognosis for recovery was, of course, poor due to the extensive liver damage as a result of the marked biliary obstruction. It would probably have

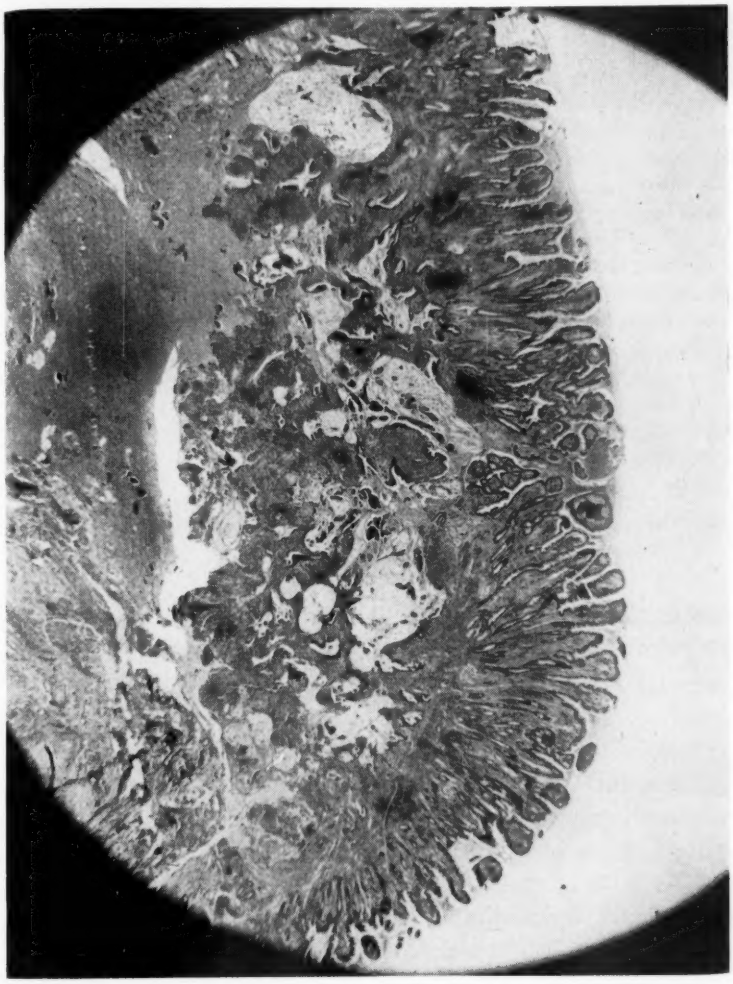

Fig. 4.—A typical overgrowth of glandular epithelium arising in the lining of the duodenum. On the right is the lining minus the desquamated covering of the epithelium, but the papillary stroma remains. The remainder of the specimen is loose fibrous tissue which is partially granulation tissue within which are glands of different sizes and shapes lined with epithelium increased in staining quality but still arranged fairly regularly and retaining its basal polarity. It was demonstrated in other parts of the surgical specimen that similar atypical glands were invading the submucosa and muscularis. This represents a low-grade (grade 1) adenocarcinoma. No pancreas is present in the specimen.

been better to have drained only the gall bladder at the first operation and then performed a more extensive operation at some future time with the patient perhaps in better condition.

ULCER OF THE DUODENUM AFFECTING THE AMPULLA OF VATER

Ulcer of the duodenum affecting the ampulla of vater is a rather rare condition which may come about as a result of a primary ulcer in this region or as a result of marginal ulcers following various gastroedemic anastomoses for intractable ulcers of the stomach or first portion of the duodenum.

CASE 4 (Hosp. No. 442882).—A 46-year-old man entered the hospital in August, 1944, with a history of two years of intermittent epigastric pain but no jaundice. Roentgenography showed a nonfilling gall bladder without stones. The laboratory findings were not significant. At surgery a contracted gall bladder was found. There was no duct obstruction or dilatation of the ducts. Because of the small gall bladder it was drained. In December, 1944, due to a persistent draining biliary sinus tract and jaundice, exploration was again attempted. No stones were found in the ducts or ampulla. A T tube was placed in the common duct. Repeated diodrast studies failed to show any duct obstruction. The tube was removed after some months, and for a period of time there were occasional transitory pain, jaundice, and clay-colored stools which persisted until November, 1945, when there was a severe intestinal hemorrhage with the finding after transfusion and vitamin K treatment of a duodenal ulcer which was treated medically until Jan. 1, 1946. At this time laboratory findings of importance were icteric index of 50 and 4 plus occult blood in the stool. On Jan. 2, 1946, operation was again instituted at which time the common duct was opened and yielded green viscid bile. The duodenum was opened, and an ulcer ½ to 1 cm. in diameter was found 3 cm. above the ampullary ostium on the ventral side in the duodenal mucosa. The ulcer was incised and the edges were approximated. A choledochojejunostomy was performed and a drain placed in the right renal fossa. The incision was repaired in the usual manner. The diagnosis at this time was (a) duodenal ulcer involving and obstructing the ampulla and (b) some anomalous condition of the biliary tracts not discernible at operation.

The patient made an uneventful recovery with an icteric index of 2, normal stools, a disappearing jaundice, and a weight gain of thirteen pounds three months later.

FINAL SUMMARY

Four cases have been presented, each of a different pathologic nature, but with marked similarity of symptoms and findings, such as persistent jaundice, pruritis, anorexia, weight loss, and stool color changes. Because of such similarities and the great difference in prognosis, the following conclusion is expounded: In those patients with biliary tract obstruction producing symptoms and physical findings which cannot be readily explained by the simpler, less hazardous means, the surgeon is thoroughly justified in exploring the ampulla of Vater transduodenally, and in agreement with Brunschwig[5] transduodenal resection with reimplantation of the ducts with, or in the absence of, internal biliary drainage should be the choice for ampullar carcinomas of 1 cm. or less in diameter that appear quite circumscribed or show little gross evidence of infiltration and which do not extend into the pancreatic tissue.

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ENTEROGENOUS CYSTS OF THE DUODENUM

Case Report and Review of Literature

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DESPITE the rarity of enterogenous cysts of the duodenum, the surgeon should be capable of recognizing them and should be acquainted with the proper methods of treatment. Generally encountered unexpectedly at laparotomy, these cysts may be confused with other lesions and their true identity may escape both surgeon and pathologist. The limited data available for discussion of this topic necessitate a complete review of the literature. We are also reporting a recently encountered case of our own, interesting because of successful treatment by a method usually not applicable.

The outstanding features of the case herewith cited are as follows: A 12-year-old boy suffered recurring attacks of partial high intestinal obstruction since the age of 1 year and passed tarry stools just prior to admission. Abdominal examination was negative. Roentgen-ray study revealed an obstructive lesion in the duodenum. An enterogenous cyst of the duodenum was successfully treated by excision from within the lumen.

CASE REPORT

L. A., a white male, age 12, was admitted to the medical ward of the Jefferson Medical College Hospital on Feb. 6, 1945, with the chief complaints of abdominal pain, vomiting, and the passage of tarry stools.

Since the age of 1 year the patient had numerous episodes of vomiting, often of such severity that his face became livid. During these attacks the infant doubled up, apparently from pain. At the age of 5 years it became established that the pain occurred in the epigastrium and right upper quadrant. It came in waves with peaks of intensity and intervening periods of relief lasting several minutes. These attacks occurred at any time, sometimes while the patient was eating, sometimes several hours after a meal, and occasionally at night. The vomitus contained recently ingested food and was seldom large in quantity. Recovery from these episodes was always prompt and the appetite remained good. This syndrome was diagnosed as appendicitis several times. On one occasion, when the boy was 9 years of age, elective appendectomy was prevented only by the sudden development of scarlet fever.

Two weeks before admission to the hospital the boy began to experience the pain and vomiting several times daily. These attacks were unrelieved by powders prescribed by the physician. The mother noticed two days prior to admission that the boy was passing tarry stools. On questioning, he stated that the stools had been dark for several days.

There were no symptoms referable to other systems and the past medical and family histories were noncontributory.

Physical Examination.—The patient was moderately obese, very pale, and apprehensive. The temperature was 100° F.; pulse, 120; respiration, 26; and blood pressure,

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100/50. Except for paleness of the conjunctivae as well as other mucous membranes, and a soft systolic mitral murmur, the physical examination was negative. Repeated abdominal examinations revealed no mass or other abnormality.

Laboratory Studies.—Blood count revealed: hemoglobin, 38 per cent; red blood cells, 2,400,000; color index, 0.80; white blood cells, 8,500; differential count, normal. Two per cent of the red blood cells were normoblasts and the platelets numbered 390,000. Tests of hemostatic function were normal. Repeated urinalyses were negative. Blood Wassermann and Kahn reactions likewise were negative. Stool examinations, with the patient receiving a meat-free diet, revealed strongly positive benzidine reactions.

The prothrombin time was 100 per cent of average normal; bromsulfalein liver function test revealed 5 per cent dye retention; and the serum bilirubin was 0.4 milligram. Blood culture was negative.

Roentgenologic study of the upper gastrointestinal tract with barium by Dr. Paul C. Swenson revealed the following: The esophagus and stomach were essentially normal, except for considerable pylorospasm early in the examination. This later relaxed and a normal duodenal bulb was visualized. In the second portion of the duodenum there was found an elongated filling defect which forced the barium to the periphery (Figs. 1 and 2). There was a slight irregularity at the distal portion of the defect suggestive of ulceration. The remainder of the upper small bowel was normal. There was no evidence of gastric retention at the end of six hours. These findings were interpreted as suggestive of leiomyoma in the second portion of the duodenum with ulceration.

Fig. 1.—Preoperative gastrointestinal series, showing filling defect in second portion of duodenum.

Subsequent Course.—The patient remained in the hospital twenty days, during which time he remained asymptomatic. He received three blood transfusions of 500 c.c. each on Feb. 5, 8, and 14. At the time of discharge on Feb. 24, 1945, the hemoglobin was 80 per cent, red blood cell count 4,100,000, and benzidine test of the stool negative. The boy's parents elected to take him home for several weeks, to return then as a private patient when the surgeon of their choice would be available.

Second Hospital Admission.—The patient was readmitted on April 13, 1945, to the private surgical service. He had remained asymptomatic in the interim. Blood count revealed a hemoglobin of 82 per cent and red blood cell count of 4,120,000. Repeat roentgenologic examination of the duodenum revealed the same defect at the bottom of the U loop. At this time there was no evidence of ulceration.

The preoperative diagnosis was leiomyoma of the duodenum or gastric polyp prolapsed into the duodenum.

Operation.—On April 16, 1945, under ether anesthesia, the abdomen was opened through a right upper rectus muscle-splitting incision. The duodenum appeared normal in size, but palpation revealed a semifluctuant mass about 3 cm. in diameter in the second portion along the mesenteric border adjacent to the pancreas. In order to rule out a prolapsed gastric polyp, a gastrotomy incision was made anteriorly in the prepyloric region. A finger was introduced into the lumen of the stomach. No polyp or other abnormality was noted, so the finger was advanced through the pylorus into the duodenum. Along the posterior wall of the second portion there was felt a smooth, circumscribed, semifluctuant mass, apparently arising

Fig. 2.—Spot pressure film of filling defect shown in Fig. 1.

within the wall of the duodenum and projecting well into the lumen. A longitudinal incision about 5 cm. long was made into the lumen of the duodenum through the anterior wall opposite the mass. The ampulla of Vater was located about 2 cm. above the upper limit of the mass. Immediately adjacent to the upper border of the mass the lumen of another duct presented. A fine blunt probe was inserted and passed obliquely upward readily for a distance of approximately 3 cm. into the pancreas. It had no demonstrable communication with the subjacent mass. From within the duodenum a transverse incision was made through the mucosa overlying the mass. With moderate difficulty the mass, which occupied a submucous position, was excised intact without rupturing through the posterior duodenal wall. The mucosal incision as well as the longitudinal one through the anterior wall were closed, thus re-establishing the continuity of the duodenum. Following closure of the gastrotomy incision the abdomen was sutured in layers without drainage.

The patient received 500 c.c. of blood during the operation and remained in good condition throughout. Total operating time was one hour and thirty minutes.

Pathologic Examination.—The specimen consisted of a thin-walled cyst measuring 2.3 by 2.1 by 1.5 centimeters. Slightly more than half of the external surface was rounded, smooth, and glistening, whereas the remainder was somewhat flattened, rough, and shaggy (Fig. 3). The lumen contained thick cloudy fluid.

Histologic examination revealed that the cyst was lined by a duodenal type of mucosa. The outer wall consisted of muscularis (Fig. 4).

Fig. 3.—Photograph of gross specimen.

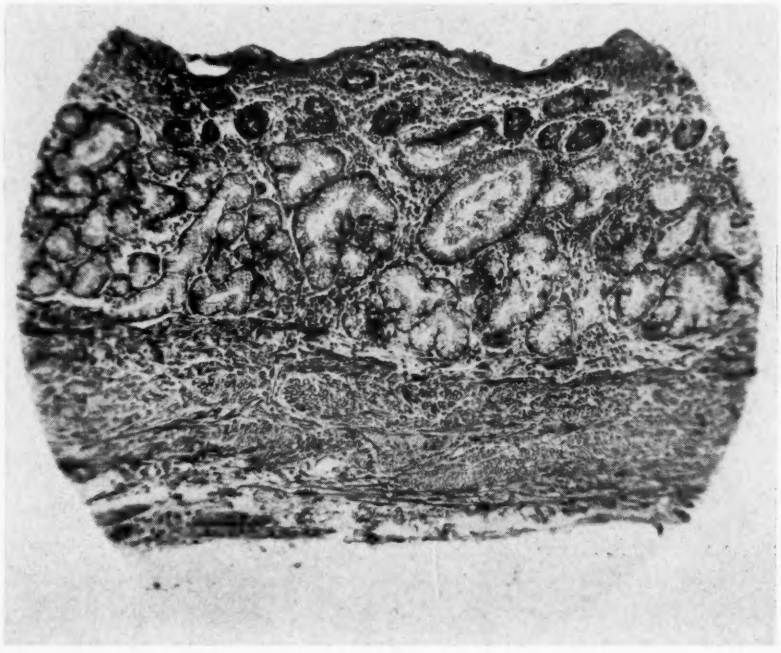

Fig. 4.—Photomicrograph (×100) of cyst wall, showing duodenal type of mucosa and well-developed muscularis.

Postoperative Course.—Wangensteen suction and parenteral feeding were instituted for six days postoperatively. The wound healed primarily and the entire convalescence was uneventful. At no time did the temperature postoperatively rise above 100° Fahrenheit. The patient was discharged in good condition on May 5, 1945, the nineteenth postoperative day.

Follow-Up.—Four months postoperatively the boy was free of pain, vomiting, and tarry stools. The wound was well healed and the patient had gained 12 pounds. Re-examination of the upper gastrointestinal tract at this time showed free egress of the barium through the pylorus and duodenum, the smooth surface in the mucosal pattern apparently being normal in the region previously shown to have extraluminal pressure (Fig. 5).

One year following operation the patient was entirely well.

Fig. 5.—Postoperative gastrointestinal series, showing normal contour in second portion of duodenum.

DISCUSSION

The rarity of enterogenous cysts of the duodenum is demonstrated by the fact that we have been able to collect only thirteen previously reported cases from the world literature. These include seven cases from the excellent previous review by Gardner and Hart,[1] one[2] from the German literature not included by these authors, and five[3-7] reported since their article. Our case brings the total to fourteen (Table I).

Of the total cases, ten were encountered between birth and the age of four months. The oldest patient was 15 years of age. The average age for the group was 3 years. Three patients were males, nine were females, and the sex of the remaining two was not mentioned. None were reported in the colored race.

TABLE I. ANALYSIS OF CASES

CASE	AUTHORS	YEAR	AGE, SEX, AND COLOR	OBSTRUCTIVE SYMPTOMS	MASS	BLEEDING	PREOPERATIVE DIAGNOSIS	TREATMENT	RESULT
1	Sänger and Klopp[14]	1880	Birth –, W	–	–	–	–	None	Died at birth
2	Roth[15]	1881	Birth M, W	–	+	–	–	None	Died at birth
3	Meyer[16]	1919	3 wk. F, W	+	–	–	Pylorospasm	None	Died
4	Waugh[17]	1923	19 days F, W	+	+	–	Duodenal obstruction from abdominal tumor	First, cyst opened and packed with gauze; second, cyst marsupialized	Refilled in eight weeks Died six days postoperatively
5	Maddox[10]	1927	3 mo. –, W	+	+	–	–	Exploratory laparotomy	Died sixteen hours postoperatively
6	Sohn[2]	1927	8 yr. F, W	+	+	–	Intussusception	Resection of pylorus and first part of duodenum	Well
7	Smith[18]	1930	2 wk. F, W	+	+	–	Pyloric stenosis	Cyst drained externally	Died one week postoperatively
8	Gardner and Hart[1]	1935	15 yr. F, W	+	+	+	Choledochus cyst	Window anastomosis of cyst and duodenum	Well
9	Ladd[3]	1937	5 wk. F, W	+	+	+	Mesenteric, omental, or enteric cyst	Resection of cyst and first portion of duodenum; posterior gastrojejunostomy	Well
10	Basman[4]	1938	4 wk. F, W	+	+	+	Hypertrophic pyloric stenosis	First, cyst aspirated; second, seventh day: posterior gastrojejunostomy	Well
11	Pachman[5]	1939	4 mo. F, W	+	+	–	Cyst of the abdomen	Biopsy of cyst wall; catheter drainage	Died four hours postoperatively
12	Gillespie and Rogers[6]	1940	4½ yr.	+	+	–	–	Excision of tumor; closure of duodenum; T tube drainage of common bile duct	Well
13	Orgias[7]	1943	4 wk. F, W	+	+	–	Mesenteric cyst causing pyloric obstruction	Resection of part of stomach and duodenum, with end-to-end anastomosis	Well
14	Authors' case	1945	12 yr. M, W	+	–	+	Leiomyoma of duodenum	Excision of cyst from within duodenal lumen	Well

Although the exact etiology of this condition has not been definitely established, authors agree that it is the result of a developmental defect. Lewis and Thyng[8] observed knoblike diverticula along the entire intestinal tract of embryos of man, the pig, and the rabbit. Though the earliest of these appeared in the region of the duodenum, the greater number subsequently appeared along the terminal ileum. Most of them degenerated. The detachment of one might account for the development of an enterogenous cyst. In support of these authors' theory is the fact that the enterogenous cysts are by far most frequent in the region of the terminal ileum, corresponding to the area in which the fetal diverticula were most frequently noted.

Hughes-Jones[9] demonstrated in human embryos the presence of islands of epithelial tissue like that of the intestine lying close to but not in the intestinal wall. It is thus possible that sequestration of embryonal intestinal epithelium early in fetal life may give rise to enterogenous cysts.

Maddox[10] favors the theory of origin from a vacuole, arising during the so-called solid stage of the intestine, which fails to gain communication with the developing lumen. Fusion of several such isolated vacuoles might also explain the development of the long tubular structures which course through the mesentery alongside of the gut and to which the term "duplications of the alimentary tract" has been applied. Ladd and Gross[11] emphasize that enterogenous cysts originate from the same kind of developmental aberration as these elongated hollow structures and prefer the all-inclusive name of "duplications of the alimentary tract" for both lesions.

In spite of the seemingly wide pathologic variations, these cysts possess three fundamental features. They are intimately adherent to some portion of the duodenum; they are cystic, containing fluid; and their walls are composed of all layers of the intestine.

In the present series there were two cases in which enterogenous cysts were present also in other portions of the alimentary tract. Five were attached to the first portion of the duodenum and five to the second portion. In four cases the exact location was not stated. The cysts were usually round or pear shaped. One was reported as pedunculated (Case 2). The size varied from 2 to 12 cm. in diameter. The largest contained 550 c.c. of fluid. Usually the fluid is clear, pale, and mucoid, representing the secretion of its own epithelial lining. Occasionally, when high intracystic pressure causes degeneration or necrosis of the lining membrane, the fluid may be cloudy or dark due to hemorrhage (Case 11). In no case was a communication with the lumen of the duodenum reported.

Multiple congenital abnormalities were noted in several instances. Case 1 exhibited multiple cysts of the intestine and biliary passages, several accessory spleens, and complete transposition of the viscera. In Case 2, similar cysts of the terminal ileum and posterior mediastinum were reported. Blind ending of the pancreatic duct in the cyst wall was described in Case 5. In our case the duct which emptied into the duodenum 2 cm. below the ampulla of Vater and adjacent to the cyst is regarded as one of the variant positions of the accessory pancreatic duct diagramed by Schmieden and Sebening.[12]

Histologic examination of the cyst wall reveals a mucosal lining which is usually duodenal in type. Occasionally, because of pressure necrosis, this lining may be partially or wholly denuded, covered by a fibrinous exudate, and the submucosa may contain small groups of mucous glands and lymphoid nodules (Case 9). It is probable that the mucosal lining may at times correspond to that at other levels in the gastrointestinal tract, since this feature has been observed in enterogenous cysts elsewhere.

The presence of a smooth muscle coat is an important constant feature of the lesion. This muscularis may be thin and attenuated (Case 5) or may be thick and well differentiated into an outer longitudinal and inner circular layer (Case 11). It is adherent to or continuous with the muscularis of the duodenum, allowing no plane of cleavage.

The duodenum does not represent the most frequent site for occurrence of these cysts. Of 102 reported cases collected by Hudson,[13] only eight were in the duodenum. Although they may occur at any level of the alimentary tract from the base of the tongue to the anus, they are by far most frequent in the ileocecal region (85 per cent of the fifty-five reported by Hughes-Jones[9]).

Encroachment upon the duodenal lumen by the intramural lesion produces obstructive symptoms. Intermittent colicky pain was a prominent symptom in our case as well as in two of the other three older patients. It was not mentioned in those reports dealing with infants. Vomiting was a constant symptom except in those patients who died at birth. The vomitus may or may not contain bile depending upon the location of the lesion with respect to the ampulla of Vater. Visible peristalsis may be observed across the upper abdominal wall and there may be some fullness in the same area. A mass was palpable in all but three cases. Melena was reported in four cases and was associated with hematemesis in one. In our case a profound anemia was produced. The bleeding occurs from ulceration of the overlying duodenal mucosa, probably due to pressure necrosis. Jaundice was present in one case, resulting from extrinsic pressure on the common bile duct. Plain roentgenogram of the abdomen may show a soft tissue mass in the right upper quadrant. Upper gastrointestinal study with barium frequently reveals duodenal obstruction and gastric retention of barium after six hours. In our case an irregularity of the filling defect suggested ulceration. Barium enema may show displacement of a portion of the colon. Intravenous pyelography may be of aid in excluding a renal tumor.

The lesion has never been specifically diagnosed preoperatively and has seldom even been considered as a diagnostic possibility. Fluctuant masses would necessitate differential exclusion of other cysts, namely, omental, chylous, dermoid, pancreatic, and choledochal. More resistant masses may resemble hypertrophic pyloric stenosis, intussusception, renal tumor, or leiomyoma. In the absence of any mass, pylorospasm and congenital duodenal diverticulum, atresia, or bands must be considered.

Treatment of these lesions is surgical. The method employed must be adapted to the individual case, being largely determined by the size and position of the cyst and by the age and condition of the patient. The ideal procedure, excision of the cyst, is usually mechanically impractical because of continuity

of the muscle layers of the cyst and duodenum. In addition, it is dangerous because the cyst and adjacent duodenum have a common blood supply. Injury to these vessels during excision of the cyst might lead to gangrene of the bowel wall. That such a procedure may be employed with success in some instances is illustrated by our case in which the cyst was excised from within the duodenal lumen and by the case of Gillespie and Rogers[6] in which it was excised from without.

Resection of that part of the duodenum bearing the cyst followed by re-establishment of continuity of the gastrointestinal tract provides complete cure (cases of Orgias[7] and Sohn[2]) but is not feasible when this would involve the pancreatic and biliary ducts. It is a formidable procedure in an infant or debilitated child. In such poor risk cases internal drainage may be provided by window anastomosis of the cyst to the adjacent dudenal lumen, as successfully performed by Gardner and Hart.[1] These same authors have suggested a more complicated form of internal drainage by anastomosis of the cyst to a loop of jejunum, the segments of which are united by a jejunojejunostomy. The fecal stream is thus diverted from the cyst.

Although not a method of choice, marsupialization of the cyst, particularly if large, could be undertaken if other procedures appeared unduly hazardous. Aspiration or catheter drainage are mentioned only to be condemned. Relief of obstruction by gastroenterostomy, without carrying out any procedure on the cyst itself, was successfully employed in one case.

Accurate evaluation of the over-all mortality (50 per cent), as well as the merits of the various operative procedures, is impossible due to the small number of cases. However, it is apparent that the high mortality is due to the extreme early age of the average cases and the frequently poor preoperative condition of these infants. Of the ten patients whose ages ranged from birth to four months, three died at birth or shortly thereafter and only three of the remaining seven recovered following operative procedures. On the other hand, all four of the older patients recovered following surgical treatment.

The immediate and ultimate prognosis in the older age patients is apparently good. The high mortality to date in the infant group may perhaps be reduced in the future by stricter attention to pre- and postoperative care in cooperation with a competent pediatrician.

SUMMARY AND CONCLUSIONS

1. Enterogenous cysts of the duodenum are exceedingly rare. We are reporting the fourteenth case.

2. These congenital cysts originate as developmental defects. They contain all the coats of the bowel and their muscularis is continuous with that of the duodenum.

3. The diagnosis should be considered when an infant or child presents symptoms of duodenal obstruction. A mass may be palpable in the upper abdomen, and occasionally melena may be noted. Roentgen-ray examination may be a valuable diagnostic aid.

4. Simple excision, though rarely possible because of continuity of the muscle layers, was successfully performed in our case. Excision of the cyst usually requires resection of that portion of the duodenum bearing it. If the patient's condition or the location of the lesion do not permit resection, internal drainage or gastrojejunostomy are advocated. Results of external drainage are poor.

5. Proper choice of operative procedure for the individual case coupled with meticulous pre- and postoperative care may lower the high mortality in the infant group. The prognosis is excellent in older patients.

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INTRAPERITONEAL HEMORRHAGE COMPLICATING SIMPLE LARGE BOWEL OBSTRUCTION

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THE effects of bowel distention, both in experimental animals and clinical cases, have been the subject of extensive study during the past twenty-five years. As a result, fanciful theories on the nature of the "absorbed toxins" have been replaced gradually by logical, mechanical concepts. To Owen H. Wangensteen goes much of the credit for the emphasis on the mechanical aspects of bowel obstruction.

It has been our experience to encounter an effect of distention hitherto unreported in the literature. This complicating factor is intraperitoneal hemorrhage arising from a subserosal vein and is self-limited in extent. We report herein two cases of large bowel obstruction of the closed loop variety. The intraperitoneal hemorrhage arose, in each case, from the anterior cecal vein which crosses the cecum at right angles to the long axis of the bowel, at or near the level of the ileocecal junction.

CASE REPORTS

CASE 1 (A-63041).—E. B., a 79-year-old white woman, was admitted to the surgical service of the Queens General Hospital on March 18, 1943, complaining of lower abdominal pain. The pain had been colicky in nature and located in the umbilical region at its onset thirty-six hours before. Ten hours after the pain began the patient vomited food particles. She vomited several times thereafter and noted brownish, "bad smelling" vomitus. She passed no stools after the illness began but continued to pass some flatus.

Past History.—During the preceding three years the patient had lost 35 pounds in weight. The stools had always been well formed and regular up to the present illness. Six months before admission she noted occasional bright red blood in the stools. For thirty years the uterus had been prolapsed but caused the patient no particular inconvenience.

Physical Examination.—The patient was emaciated, elderly, and of small stature, and appeared to be in moderate distress. History taking proved to be difficult because of her poor hearing, but she was well oriented and alert. The temperature was 100° F., pulse 88, and blood pressure 130/70. The tongue was coated white and the breath was fetid. The heart was not enlarged, and the rhythm was the regular sinus type. No murmurs were detected. The lungs were similarly devoid of pathology. The abdomen was slightly distended. Spasm of the recti muscles was present in moderate degree. Tenderness was diffuse but most intense in the right lower quadrant. A vague impression of a mass in the right lower quadrant was masked by muscle spasm. The rebound phenomenon was most notable in the same area. Auscultation failed to reveal any borborygmi and a "silent" abdomen was diagnosed.

Rectal examination added no further information.

Vaginal examination confirmed the presence of a complete uterine procidentia with marked erosion of the cervix.

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Laboratory Data.—Tests revealed: white blood cells, 18,500; polymorphonuclears, 80 per cent; red blood cells, 3,800,000; hemoglobin, 65 per cent.

Urinalysis revealed no abnormal elements.

Working Diagnoses.—Diagnoses were: (1) acute appendicitis with perforation; (2) neoplasm of the colon with perforation; and (3) diverticulitis with perforation.

Course.—The patient was placed on Ochsner regime with Wangensteen suction via duodenal tube. Fluids and electrolytes were restored. After ten hours of such therapy and observation further delay was considered dangerous and the condition optimal. At this time signs of pathology were well localized to the right lower quadrant.

Operation.—Anesthesia consisted of 1 per cent procaine field block supplemented in the later stages by cyclopropane. The abdomen was entered via a McBurney incision. Upon opening the peritoneum bloody fluid gushed out. After suctioning, the cecum was found to be much distended and its anterior surface hematomatous. The cecal serosa was split in the long axis of the bowel, close to the anterior longitudinal band. The edges of the split serosa were approximately 2 cm. apart. Palpation of the ascending colon revealed an annular obstructing carcinoma at the level of the hepatic flexure. The appendix was normal. A clamp cecostomy was performed and the wound was closed in layers about the exteriorized bowel. Postoperatively, Wangensteen suction was continued. On the third day the clamp came loose with subsequent outpouring of gas and feces. Thereafter drainage was profuse and uninterrupted. The patient was gotten out of bed early and frequently. There were no postoperative complications.

On April 9, 1943, she was reoperated upon. Obstructive resection of the hepatic flexure was performed using intercostal block anesthesia. She was permitted out of bed on the first postoperative day and daily thereafter. Spur crushing was begun two weeks later. On June 11, 1943, colostomy closure was performed. Stools were passed rectally after the third postoperative day. The cecostomy failed to close spontaneously, necessitating surgical closure. The patient left the hospital on Aug. 22, 1943, and is now living in a home for the aged. Microscopic report on the resected tumor was adenocarcinoma grade 2 C.

CASE 2 (A 6841).—C. M., a 59-year-old white man, entered Queens General Hospital on Jan. 21, 1940, complaining of pain in the abdomen of twenty-four hours' duration. Ten days before admission he had a bout of colicky pain which lasted one and one-half days and which he attributed to the eating of "hot dogs." There was no nausea or vomiting. Self-treatment with "salts" resulted in several bowel movements and relief from pain. There were no further symptoms until the night before admission, when sharp epigastric pains began and were followed shortly by vomiting. After several hours the epigastric pains subsided but a residual soreness was noted in the right lower quadrant. The patient noted a "blown up" appearance in that area. The soreness persisted there causing him to seek relief by the taking of salts. A normal bowel movement resulted after several hours.

Past History.—Iridectomy was done thirty-five years before for sequela of trauma. Three years prior to this illness hematemesis occurred and the patient entered a neighboring hospital. He requested his release before a diagnosis could be established. There was no recurrence of bleeding, no weight loss, and no further stomach trouble since that time. He reported daily and copious drinking of beer and whisky.

A mild degree of constipation during the preceding year had been amenable to mild cathartics.

Physical Examination.—The patient was a well-nourished and well-developed white man of stated age who appeared to be in slight distress. Temperature was 99.6° F., pulse 100 and respirations 16. The right eye was marked by an old iridectomy scar. The chest was emphysematous in type, but no pulmonary pathology was demonstrable. The heart was not enlarged and no murmurs were heard. The rhythm was regular and slightly rapid. The abdomen was diffusely tender with greatest sensitivity found over McBurney's point. A definite prominence in the right lower quadrant was partly masked by rigidity of the right rectus muscle. This mass was thought to be cecum.

Laboratory Data.—Tests revealed: white blood cells, 14,000; polymorphonuclears, 89 per cent; red blod cells, 4,110,000; hemoglobin, 110 per cent.

The urine was unaltered.

Working Diagnoses.—Diagnoses were: (1) appendical abscess and (2) carcinoma of the colon.

Operation.—The operation was performed under spinal anesthesia, using 150 mg. novocain. The abdomen was entered through a McBurney incision. The cecum and transverse colon were found markedly distended. A large amount of frankly bloody fluid was found in the general peritoneal cavity. The serosa of the cecum was split in the long axis of the bowel and subserosal hematoma was noted.

A second incision, a right rectus, was made. Further exploration revealed an annular obstructing carcinoma of the transverse colon close to the splenic flexure. Clamp cecostomy was performed inasmuch as distension precluded resection and end-to-end anastomosis.

Subsequently, the tumor bearing bowel was resected at another operation and end-to-end anastomosis performed. The cecostomy was closed later. This patient returned after two years with recurrence of obstruction. Diffuse metastatic carcinoma was discovered at laparotomy. He died in 1943. Microscopic report on the resected tumor was adenocarcinoma grade 1-2 B.

DISCUSSION

An explanation for the site of hemorrhage is obtained in part from Wangensteen's formula[1] for tension in a hollow viscus; $T = \pi DP$; or the tension (stretch) on each centimeter of bowel wall equals the product of pi (3.14), the diameter of the bowel, and the intraenteric pressure. In this way it is shown that the cecum is subjected to the greatest stress in closed loops, because its diameter is greatest. However, the thickness and elasticity of the bowel wall are also factors which must be considered. The cecum is an elastic, peristaltic organ which at some point becomes fatigued and then overstretched beyond its normal limit of elasticity. Further complication arises from the difference in elasticity of the various layers of the bowel wall.

Clinically, gangrene and perforation of the cecum have been noted many times in cases of obstructing carcinomas of the large bowel distal to the cecum. Before gangrene and perforation occur, it is reasonable to assume, and has been noted experimentally and clinically, that the serosa splits. Thus, its action as a limiting membrane is lost and the mucosa, which is relatively more elastic, distends further. The blood vessels which course through the subserosal tissues, particularly the veins, are stretched beyond their limit of elasticity and consequently rupture.

Age, with accompanying sclerosis, is a probable predisposing factor. With the rupture of the vessel, hemorrhage occurs into the subserosal tissues and, by direct extension, into the peritoneal cavity. Bleeding is self-limited due to retraction of the vessel.

With the onset of hemorrhage into the general peritoneal cavity, the patient presents an acute abdominal syndrome. The findings of muscle spasm and excessive tenderness with rebound phenomenon are not the usual signs of simple obstruction. Gangrene of the bowel and perforation of the cecum or of carcinoma elsewhere are to be considered more logically. The hematomatous cecum gives rise to such well-localized tenderness that appendicitis will inevitably be considered in the diagnosis. When operation is performed copious bloody fluid

will be found in the peritoneal cavity, sometimes in sufficient amount as to pour out on incision of the peritoneum. Further examination then reveals the cecal vessel as the site of hemorrhage and the presence of obstruction in the ascending, transverse, or descending colons.

Review of the literature for the past thirty years failed to uncover any reports of similar cases. This pathology is not included among the effects of distention by Wangensteen.[1] Dr. Wangensteen states[2] that he has never seen this entity. We feel that cause and effect are fairly well linked in both cases reported and that the mechanism postulated is a logical one. We believe, too, that it is related to abdominal apoplexies[3] in that sclerotic changes are predisposing factors. The exciting factor is, of course, the distention consequent to organic obstruction.

The awareness on the part of surgeons as to this possible complication of large bowel obstruction, particularly in older age groups, may lead to better diagnosis and avoidance of improper incisions, poorly timed operations, and unnecessary morbidity.

CONCLUSION

Two cases of large bowel obstruction with marked distension of the cecum are presented, which apparently have led to stretching of the anterior cecal vein with regional hematoma and intraperitoneal hemorrhage. The theoretical bases for this lesion is discussed. No previous complication of this nature was found in the literature.

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TANTALUM CRANIOPLASTY, A METHOD FOR ONE-PIECE FIXATION

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TANTALUM used as the "graft" in cranioplastic procedures has definite advantages over any material previously employed. Since it has been used with increasing frequency and seems to enjoy only favorable reports, I consider it worth while to describe a new method of fixation which is suitable for use with this metal, simple to accomplish, and definitive.

INDICATIONS FOR CRANIOPLASTY

The indications for cranioplasty are well agreed upon by neurosurgeons in this country. Grant and Norcross[1] listed them as follows:

1. Severe headache and other *symptoms of the trephined;* dizziness, undue fatigability, vague discomfort at the site of the defect, a feeling of apprehension and insecurity, mental depression, and intolerance to vibration.
2. Epilepsy, when the attacks originated from the injury that caused the defect.
3. Those cases in which there is danger of trauma at the site of the defect.
4. Cases that have unsightly defects.
5. Defects that pulsate unduly or that are painful.

Mayfield and Levitch[2] were not impressed by any relief from epilepsy following the repair of the cranial defects but remained in exact accord as to the other indications.

In the absence of contraindications which are well defined as (1) infection, (2) foreign body, (3) increased cerebrospinal fluid pressure, (4) pathologic cerebrospinal fluid changes, (5) further intracranial surgery planned through the same approach, and (6) a systemic condition contraindicating any surgery, I feel that there should be only one indication for cranioplasty, namely, *a defect in the skull.* Of course, this dogmatic statement is to be modified as individual cases merit. Generally, those defects less than 2.5 cm. in diameter need not be closed since their effect on the brain is negligible. In 1932, Reed[3] first suggested this sole indication for cranioplasty when he said, "The operation is so safe, so easy to perform, and in most cases gives such satisfactory results that every adult patient with such a defect should be given the benefit of a plastic repair." Since he expressed this opinion tantalum has made the operation even simpler and safer. In his article he described a patient with severe Jacksonian seizures who was markedly relieved by a bone graft done after the method of Frazier. Since he had never observed such results in prior surgery, and since in this patient's very large defect, movement and bulging of the brain were apparent, he surmised, " . . . . . the stopping of the attacks following the stabilizing of the brain within the skull by closing the defect makes me feel that the cause of the attack may be due more to motions of the brain from this instability

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than to adhesions between the brain and dura.'' This opinion agrees wholeheartedly with that of Gardner[4, 5] who pleaded for early closure of all skull defects.

The brain is normally a nonpulsating organ and when significant sized defects in the skull exist it is transformed into a pulsating mass which leads to definite pathologic changes in the brain tissue near the defect. Whether these changes, which may be as marked as the formation of definite cerebral cysts, are due to pulsation, herniation, or change of circulatory characteristics need not be argued. The conclusion remains: to avoid these abnormal reactions, all skull defects should be closed as early as possible.

THE CHOICE OF A BONE SUBSTITUTE

A substance used to replace bone in skull defects, and the procedure used to implant it, should have the following characteristics:

1. Material readily available
2. Material easily molded into intricate contours when needed, either by the cast and die method or by shaping at the operating table.
3. Material of similar rigidity, strength, and protection to the bone which it replaces
4. No special tools required to cut or trim at the operating table
5. Procedure easy, uncomplicated, and fast
6. Lack of any reaction between the substance used and the body tissues
7. Immobility after insertion
8. No uncomfortable side-effects on the patient; that is, heat or cold absorption, too weighty, etc.

That tantalum fits these requirements has been shown by many past studies, as those of Pudenz[6, 7] and others. He has shown that there is almost no foreign body reaction even when tantalum is placed within the substance of the brain; it produces much less reaction than other foreign substances used in neurosurgery; the encapsulation which does occur is minimal and nonprogressive; and normal regeneration of bone in the vicinity of the plate is not impaired. Many authors have pointed to the ease with which tantalum is used in surgery.

NEED FOR FIXATION

It is generally agreed that plates which depend solely on the overlying galea and skin for fixation are likely to slip out of place, sometimes to a marked degree. Gardner[5] reported two such cases which required reoperation and one instance in which even wire sutures snapped and allowed the plate to wander. The possibility of elevation by the accumulation of fluid below the plate is ever present and for this reason alone some form of fastening of the metal to the skull should be used. Various methods which have been reported for fixation of metal to the cranium are shown diagrammatically in Fig. 1. Since an elevation of 0.015 inches cannot be palpated below the scalp, I think it unnecessary to spend the time at the operating table fashioning a ledge around the entire circumference of a defect in order that the plate will lie flush with the bone.

This can only cause unneeded trauma and prolonged anesthesia. The use of screws to fix the plate is a popular procedure. At the present time tantalum screws are not available and the use of vitallium screws, as suggested by some, is to be condemned because of its electrolytic effects when placed in contact with the tantalum plate. Army neurosurgeons at two large neurosurgical centers are using tantalum wedges driven into the skull in the same fashion that a pane of glass is held in its frame with glazier's points.[9] These wedges either may

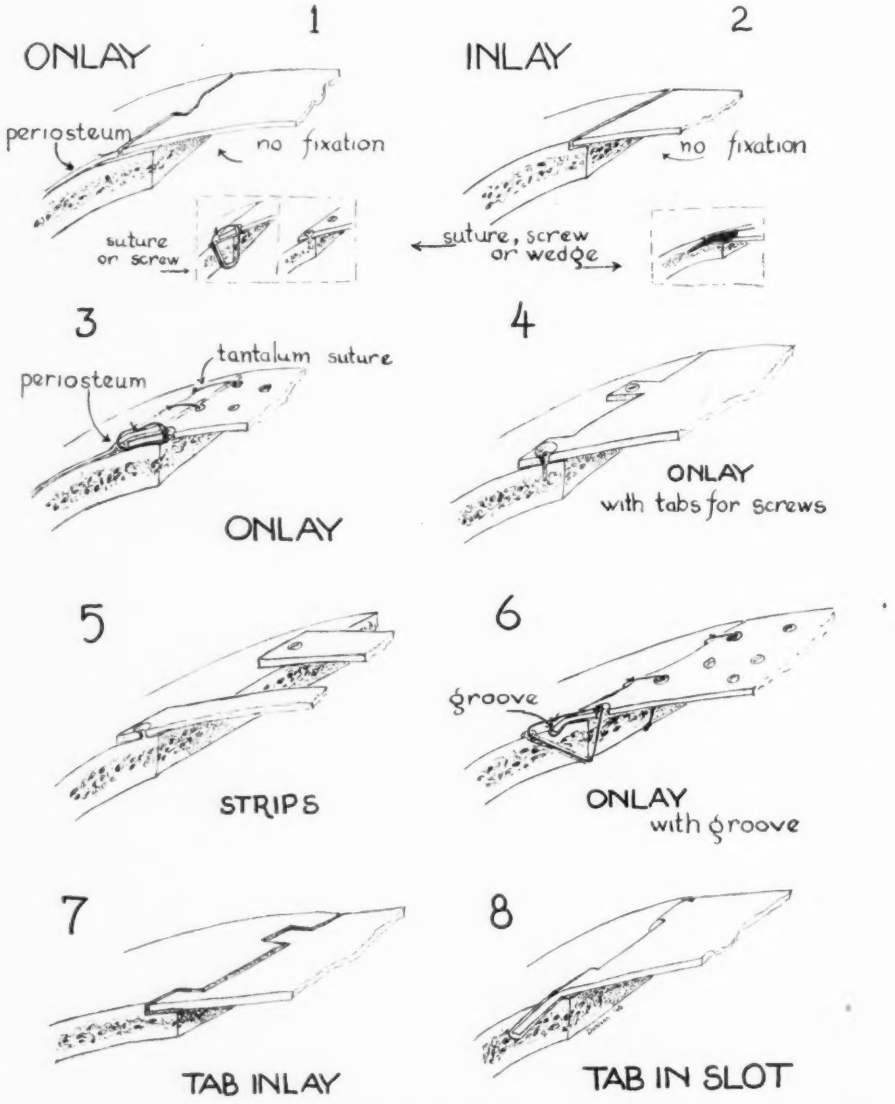

Fig. 1.—Various published methods of using and attaching metal to the skull. *1*, Without fixation, or with wire sutures or screws; *2*, no fixation, or fixed by "springing" plate into the ledge, [12-14] or by using glazier's points (inset),[9] these also may be inserted through slots cut near the margin of the plate[8]; *3*, onlay with pericranium over edge of plate[12]; *4*, onlay with projecting tabs for screws[15]; *5*, onlay strips with screws[16]; *6*, onlay with plate edges buried in groove[2]; *7*, tabs inlaid into skull with outline of plate fitting loosely within defect[17]; *8*, method proposed in this paper.

be inserted over the edge of the plate and into the outer table of the skull or may be driven into the bone through slots cut around the periphery of the plate.[8] It is probable that more tantalum cranioplasties have been performed using this method than with any other. The question that comes to mind in the use of these points is whether or not they will all remain permanently affixed to the skull. Probably a few of these pieces of tantalum have worked loose from the skull, and in instances where they were inserted on the inner surface of the plate[9] they would be a definite hazard. Wire is not always easy to insert through the skull. The aggravating habit that wire has of breaking just as the knot is being tied is known to all who use it. It requires the drilling of the cranium through the inner table and this, even in the most experienced hands, carries the danger of perforating the dura.

In an attempt to find a method of fixing tantalum plates to the skull which would require the minimum of operating time and still provide a firm attachment of the plate to the skull, and which required the use of only one piece of foreign material, the procedure to be described was evolved.

PREPARATION OF THE PLATE

Tantalum plates may be prepared at the operating table by forming them in a concave bowl with a ball hammer and trimming and fitting by trial and error. This method is advocated for small defects where there is little deviation from a plane surface. Many such plates can be formed by finger pressure or the use of pliers. Larger defects are more rapidly repaired when the plate is pre-formed by swedging it into a mold made of dental stone which has been shaped by taking plaster impressions of the skull defect prior to operation.[2, 10] The larger plate shown in this article was prepared in this manner.* Autoclaving is preferred for the sterilization of tantalum.

The use of perforations is not necessary when the plate is applied by the onlay method. For the type of fixation to be described it is necessary that the plate have small tabs projecting from its periphery as may be seen in Fig. 2. At least three of these are to be used, and in very large or complicated plates more may be necessary. In most instances these tabs need be only small rectangular projections from the margin of the plate; however, when the plate is very large and will be maintained for the most part in the vertical position, and especially where the contour or the structure of the skull will not permit the use of tabs on the lower surface, it may be necessary to fashion one or two of the tabs in a hook shape. The tabs are usually made so that they are 5 mm. wide and 7 mm. long. This size varies with the size of the plate.

After the plate has been shaped to fit the defect and contour of the skull, any large projections and rough edges are smoothed with a dental abrasive wheel, or with a fine file when the plate is made at the table. Small indentations are made in the periphery of the plate just at the base angles of the tabs to facilitate accurate marking for the slots to be drilled in the skull. These indentations are formed in the plate by the use of a small "mousetail" file.

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APPLICATION OF THE PLATE TO THE DEFECT

The patient is placed on the operating table with the head on a rest which will allow unobstructed use of the operator's hands in all directions. The operative field is prepared and draped in the usual manner. This should include a prior complete head shave and the drapes sutured in place. The incision employed varies with the size and position of the defect. In any case, the pericranium is exposed and the galea reflected back from the edges of the defect for as little a distance as possible compatible with good exposure. The periosteum is incised around the borders of the defect and reflected peripherally for a distance of 1 cm. I have not considered it necessary to remove

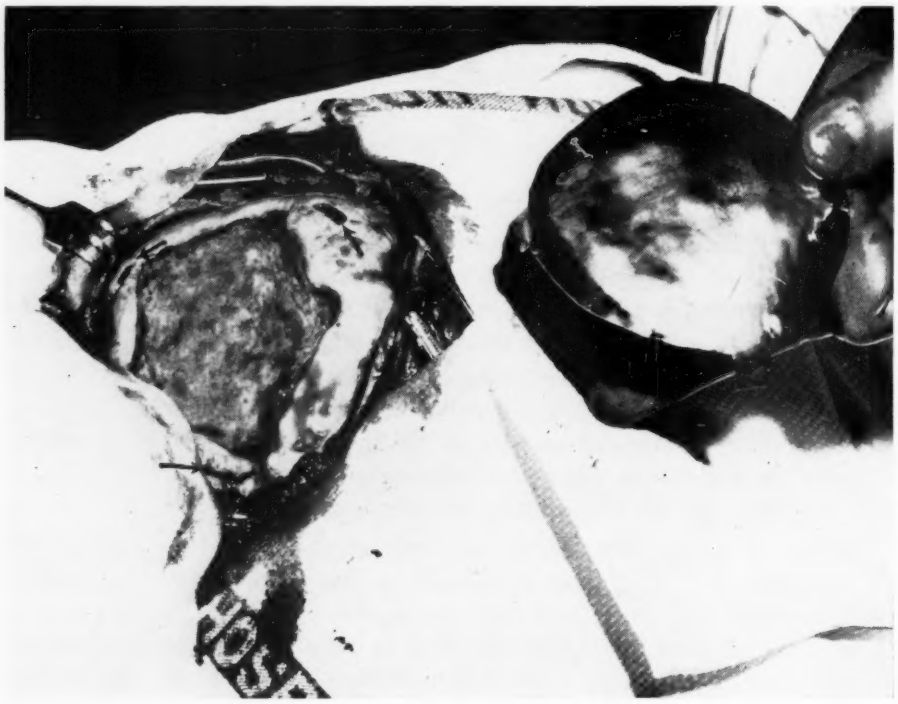


Fig. 2.—Skull prepared to receive plate. Arrows indicate slots in outer table of skull. Note the tabs on the tantalum plate. This plate pre-formed.

the scar tissue which is always found filling an old defect. Removal can only cause considerable irritation and stimulation to further growth of the scar. The scar will not continue to proliferate under the nonreactive tantalum plate and its presence serves to fill the dead space which would otherwise remain between the dura and the metal. This view is contrary to the published procedures of most neurosurgeons but it supported by the experiences of Adson[11] who places many of his plates just beneath the galea without disturbing the periosteum or the underlying scar. He points out that only where signs of cerebral irritation exist is it necessary to resect the meningeal scar tissue and, if needed, the cerebral scar. Next, the plate is placed over the defect and any minor alterations on the plate may be made at this time. The positions of the

tabs are marked on the skull by placing the tip of a small nail drill (as is manufactured for releasing subungual hemorrhage) in the indentations at the base angles of the tabs. In this way two marks are made on the skull to indicate the extent and exact position of each tab base.

A slot is then cut tangentially into the skull from one base mark to the other. This slot is directed at a very wide angle into the skull so that the tips of the tabs will lie in the diploic space. One must be cautious in drilling that the inner table of the skull is not perforated.

The slots are easily formed by using a small twist drill to drill three holes into the skull for the required distance. A small dental chisel is then used to remove the partitions between the holes. This method was used in two of my cases (Fig. 2). No special tools are needed for this procedure, but it requires a few minutes more to do than when the slots are cut with a dental engine and hand piece. The latter method has proved very satisfactory and two standard dental burrs are necessary. The initial drilling is done with a No. 2 burr which bores a tubular opening to the necessary depth. Into this opening a No. 557 burr is inserted. This instrument has a side cutting surface 5 mm. long and can cut laterally in the skull easily with gentle pressure. By sliding this burr in and out while cutting, one can cut slots to a depth of 1 cm. easily. When this method is used, slots are cut narrower and more perfectly than by the drill and chisel. One must be careful that the side-cutting burr does not "wander" when directing it laterally.

If these slots are placed carefully, the tabs on the tantalum plate will fit into them perfectly. The last tab is inserted into its slot by "springing" the plate enough to allow the tip to enter the slot. When the plate snaps back it will be found to lie in close approximation to the skull around its entire circumference and it will be fixed firmly in place against movement in any direction. A plate anchored in this way is seen in Fig. 3. Considerable pressure is needed to elevate a plate fixed to the skull in this manner.

Absolute hemostasis is extremely important prior to replacing the scalp flap since accumulation of serum and blood is very prone to occur over the metal plate. The galea and skin are closed in layers by interrupted silk sutures.

CASE REPORTS

CASE 1.—A 24-year-old colored laborer was admitted to the Oak Ridge Hospital June 14, 1945, with an extensive left temporal laceration (Fig 4*A* and *B*). This was treated and the patient sent to bed for observation. A large protuberance had been noted in the right occipital area. It was hard, fixed, and nontender and had been present five years. Since it was located just where a hat brim would strike and had caused the patient a moderate amount of distress, he expressed a desire to have it removed. General, neurologic, funduscopic, visual field, and laboratory examinations were normal. Roentgenogram revealed a large bone tumor of the right occipitoparietal area.

This tumor was removed at operation June 27, 1945. Six months later a pre-formed tantalum plate was placed over the defect by the tab-in-slot method. In spite of meticulous hemostasis there was a marked formation of fluid and collection of dark blood under the flap which required daily postoperative aspirations for two weeks. This ceased abruptly in the third week and the wound required no care after that.

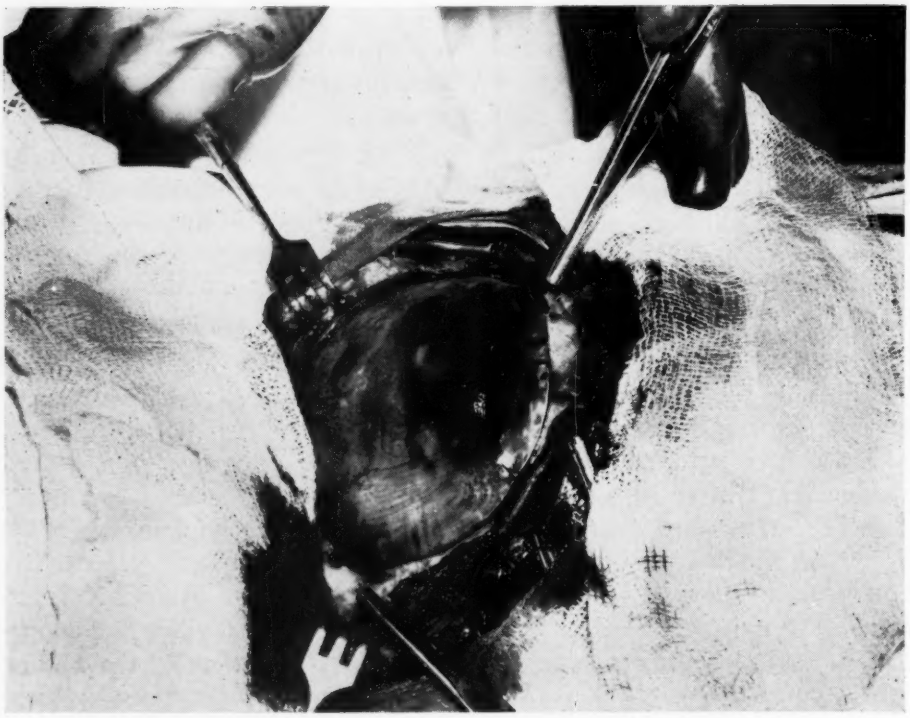
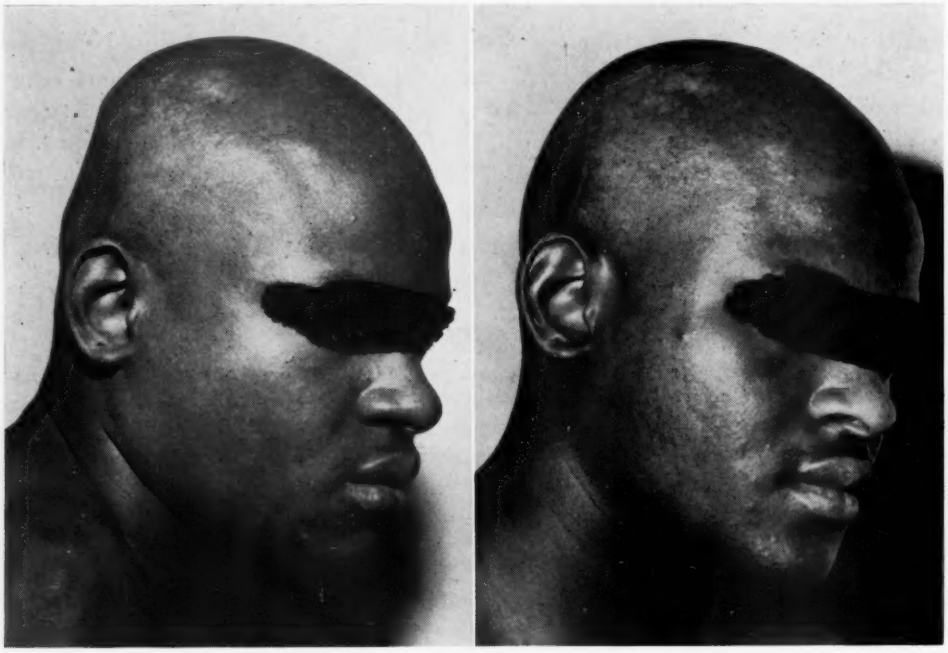
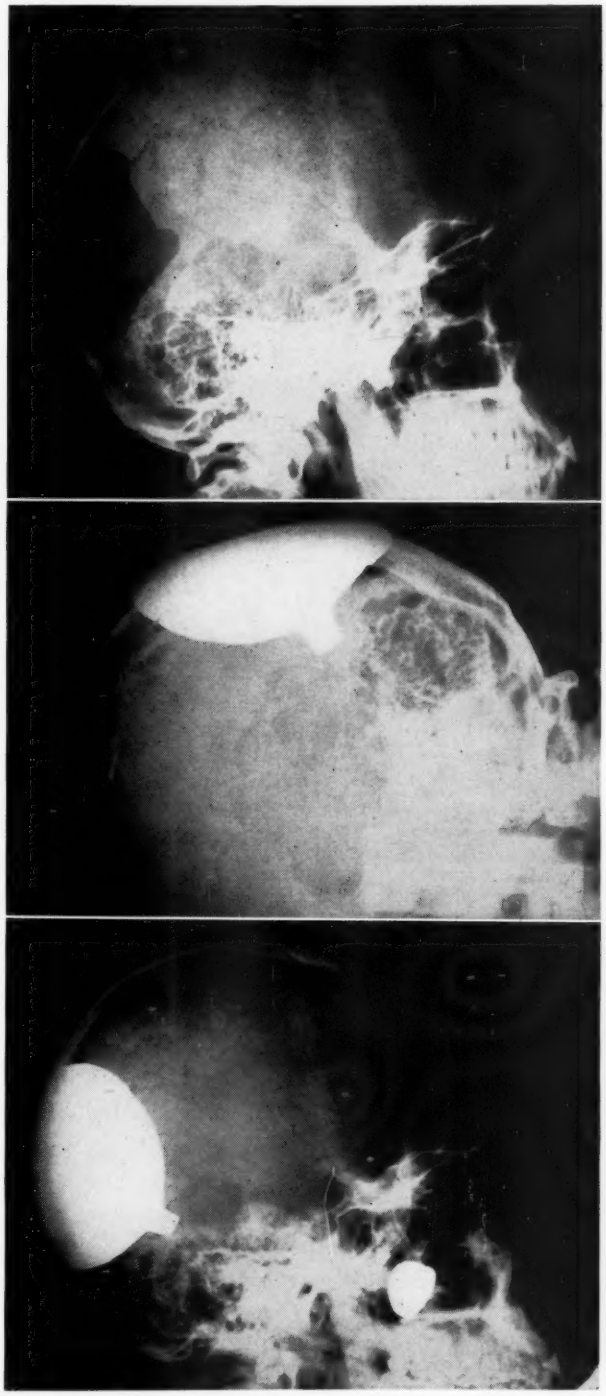


Fig. 3.—Tantalum plate in place; Kocher clamps indicate fixation points.



A. *B.*

Fig. 4.—Pre- and postoperative appearance of skull defect; *A*, preoperative, *B*, postoperative.



A.

B.

C.

Fig. 5.—Appearance of skull by x-ray before and after plating. *A*, Preplating defect; *B*, tangential view of plate in place, note close approximation at plate edges; *C*, lateral view of skull with plate in place.

The patient works in the Oak Ridge Hospital and daily cursory examinations have been possible. The plate remains solidly anchored in place and the scalp stays firmly against it. The patient is not aware of the presence of the plate, and he has no complaints referable to the operation (Fig. 5*A*, *B*, and *C*).

CASE 2.—A 46-year-old millwright was seen at the Oak Ridge Hospital Aug. 27, 1945, with a severe, depressed, compound, comminuted skull fracture just to the right of the mid-sagittal line in the mid-parietal region (Fig. 6). Because of the contamination and comminution of the fracture, it was necessary to remove the bone fragments at the time of initial operation. Since the defect measured only one and one-half inches in diameter, it was considered unnecessary, at that time, to repair it. Recovery was uneventful but the patient expressed a constant fear of further injury to the "soft spot" and was worried by the depressed scar which resulted.

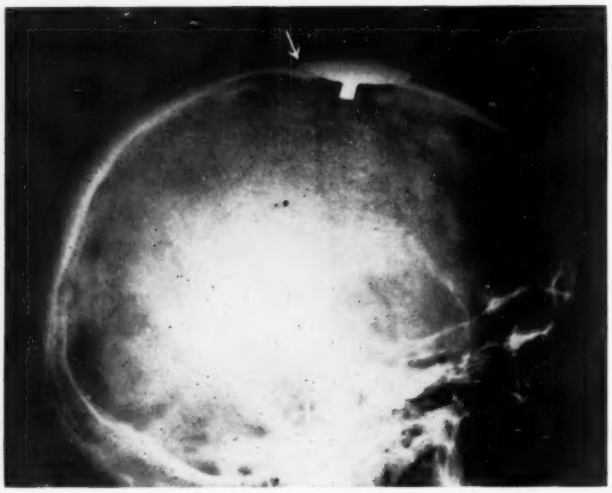


Fig. 6.—Small tantalum plate in place; note where arrow indicates the tip of one tab placed exactly in the diploic space.

For these reasons a tantalum plate was applied over the defect Dec. 13, 1945. This plate was formed at the operating table. Recovery from this procedure was without incident. The patient has had no complaints and it is impossible to palpate the plate edges beneath the scalp.

SUMMARY AND CONCLUSIONS

Tantalum is a satisfactory metal for use in skull plating.

Fixation of cranioplastic plates to the skull is necessary.

Most skull defects should be closed.

A simple, satisfactory, one-piece method for fixed metallic skull plates has been described.

Two cases are presented to illustrate this tab-in-slot fixation procedure.

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THE LATE DEFINITIVE TREATMENT OF GUNSHOT WOUNDS OF THE HEAD

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THE purpose of this communication is to recount our experience with thirty cases of missile injury to the head. These were cases in which there had been no primary débridement of the wound of the skull and brain or in which the early surgical treatment had been inadequate. They were included in a group of 4,040 battle casualties from the campaign for the Philippine Islands.* These patients were admitted to an Army general hospital in Hollandia, New Guinea, at time periods varying from eight to twenty-nine days after injury. The problem here was the surgical management of the late complications of war wounds of the head. The thirty cases which are the basis for this report, therefore, represent an unusual group in that the patients had survived the original injury as well as the rigors of water transportation for a distance of 700 to 1,700 miles. In twenty-seven of the thirty cases the complications were due to infection. In twenty-five of these the cerebritis was localized; meningitis developed in only two cases. All of these patients had been treated prophylactically with sulfonamide drugs or penicillin. Included in this report are examples of epidural abscess, cortical abscess, subcortical abscess, cerebral laceration, cerebral necrosis, depressed fracture of the skull, osteomyelitis of the skull, and combinations of these conditions. The striking similarity of the findings at the operating table in these cases served to clarify for our surgical staff the pathologic changes coincident to infection following war injuries of the head and to standardize the surgical management of such cases. All patients in this select group required operative intervention because of the development of late complications. Thus this paper deals with the late treatment of gunshot wounds of the head. The indications for operation were the signs of intracranial infection, of persistent or progressive paralysis, or of increased intracranial pressure. The fact that the series of 4,040 casualties included only sixty-two cases of skull fracture is not considered to be of statistical significance as to the frequency of cranial wounds in battle. However, it may be mentioned that the missile caused injury to the brain in forty-seven of the sixty-two cases and that late surgical complications requiring operative surgery developed in thirty of these.

General Condition of the Patients.—Twenty of the thirty patients were in fairly good general condition at the time of arrival at this general hospital. Of the other ten, one was unconscious, three were semiconscious, two showed signs of meningitis, and four were acutely ill and febrile. Significant neurologic findings included hemiplegia, paraplegia, aphasia, ataxia, cranial nerve palsy,

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*Conway, Herbert, and Coldwater, Kenneth, B.: Battle Casualties from the Philippine Islands, Surgery 20: 482, 1946.

amaurosis, and choked discs. Observation of the general condition of these patients and the state of their wounds at the time of admission to this hospital leads to a review of the therapy which was applied in the forward areas. All had received prophylactic sulfonamide therapy and in six cases penicillin had been given intramuscularly en route to this hospital. Supportive measures by means of parenteral fluids and transfusions of blood or plasma had been applied effectively from the time that the patients were seen at the battalion aid station until their admission to this hospital. Adequate neurosurgical débridement had not been done in any of these cases. Débridement and closure of the wound of the scalp had been done in only fourteen of the thirty cases. Eight of these sutured wounds became infected; six healed although there was underlying intracranial abscess. In the sixteen cases in which there had been no early operative surgical treatment, the wounds were grossly infected at the time of arrival at the hospital. In all probability the conditions of battle in which these soldiers were engaged afforded neither the necessary time nor the surgical equipment needed for neurosurgical débridement.

The medical records of many of these cases had been lost and in others the records were incomplete. Therefore, on arrival at this hospital, emphasis was placed on neurologic examination and on supportive treatment. Scalps were shaved; wounds were inspected and dressed; roentgenograms were taken to ascertain the exact location of the injury and to localize the depressed fragments of bone and the foreign bodies. All were treated with penicillin and sulfadiazine. Fluids were forced and transfusions of blood or plasma were administered as indicated. Penicillin was injected intrathecally at the time of diagnostic lumbar puncture. Careful eye, ear, nose, and throat examinations were made. In the care of paralytics, precautions were taken against the development of decubitus. Contractures were prevented by the use of splints and by physical therapy.

Operative Procedure and Findings at Operation.—The procedure in operative surgery in these thirty cases included débridement of the wound with extension of incision of the scalp in such manner as to allow for adequate exposure and for closure of the scalp without tension. Because of the nature of the skull fractures in these cases and the presence of infection, débridement of the skull was done somewhat differently than is usual in the care of fresh injuries. Through a burr hole placed about 2 cm. from the peripheral extensions of the fracture, a rongeur was inserted to remove a circular section of bone surrounding the fracture of the skull (Fig. 1). Often there was low-grade osteomyelitis of the skull. This technique afforded excellent exposure for determination of the extent of intracranial injury and infection. In some cases fragments of fractured skull were depressed but the dura mater was not penetrated. In others the dura was perforated and fragments of bone were deep in the subcortical area of the brain. The degree of injury to the skull varied from small perforations of 1 cm. in diameter, to large, stellate, comminuted, depressed fractures. Removal of the calvarium was limited to the extent of the fracture of the inner table of the skull. As in depressed skull fractures caused by injury

in civilian life, the fractures of the inner table of the skull commonly were more extensive than those of the outer table. Because of infection of the skull it was necessary in several cases to remove the bone well beyond the area of fracture. In cases in which the dura had not been perforated, an abscess of the epidural space usually was found. At operation abscesses were isolated by packing thin strips of iodoform gauze into the epidural space about the margins of the bony

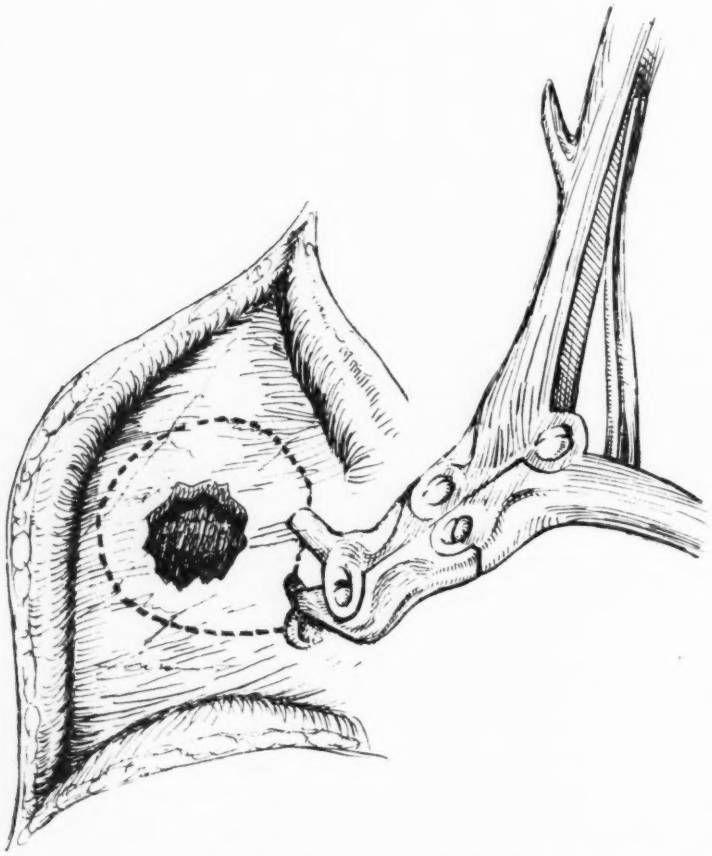


Fig. 1.—Illustrating the technique of débridement of infected skull fracture due to gunshot wounds. The central bony defect represents the point of entrance of the missile. The tables of the skull adjacent to the defect commonly are the site of low-grade chronic osteomyelitis. A burr hole at a distant site as shown allows for the removal of the infected section of bone in one piece without disturbing the granulomatous papilla which projects through it as shown in Fig. 2.

defect. In such cases the dura was not opened. The wounds were closed loosely around a soft rubber tube which was placed as a drain. In cases in which the dura had been penetrated, a fairly constant pattern was found. Through the dural defect there was a papilla-like projection (Fig. 2). This was composed of detached fragments of bone, necrotic cerebral tissue, clotted blood, hair, foreign material and granulation tissue. In most cases the dura and the pia-arachnoid were adherent to the cerebral cortex adjacent to the perforation of the meninges. After the dura was incised circumferentially around the defect, the torn and infected meninges were dissected carefully off the cortex exposing the

site of the injury to the brain. The subdural space was then sealed off by iodoform gauze packs or by electrocoagulation. The papilla and the center of the injured area were then excised using the electrosurgical knife. Pus, indriven fragments of bone, necrotic cerebral tissue, blood clots, and foreign material were removed by gentle suction and irrigation. The abscess cavity in the tract of the missile always contained the indriven fragments of bone. Commonly the missile was at a distant site in the brain or had made its exit from the skull. Let us visualize the effect of the missile. Its first impact perforates the skull carrying many small fragments of bone before it. The resistance offered by the cerebral tissue causes these fragments to lodge in the subcortical tissue while the missile continues onward. At operation the cavity was unroofed and effort was made to remove all of the fragments of bone without breaking through the wall of the abscess. Metallic foreign bodies were not removed unless readily accessible. The scalp was closed loosely about a soft rubber tube which extended into the abscess.

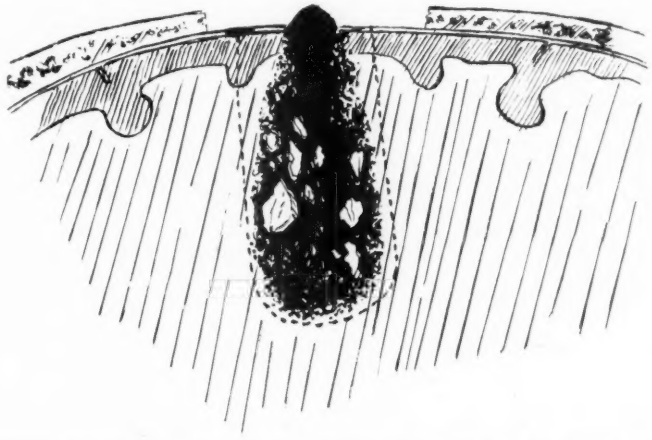


Fig. 2.—Sketch showing the papillary projection through the torn dura following removal of the section of perforated skull as shown in Fig. 1. In cases of cortical and subcortical abscesses due to gunshot this papilla was a constant finding. It was composed of depressed and detached fragments of bone, necrotic cerebral tissue, clotted blood, hair, foreign material, and granulation tissue. The comminuted fragments of skull are driven into the subcortical area. Apparently they are driven varying depths by the force of the missile. As the missile proceeds to a distant site in the brain or makes its exit from the skull, these bony comminutions form a pattern suggestive of the tail of a comet. The abscess is found around these depressed fragments of bone, not around the missile.

Intracranial abscess (epidural, cortical, or subcortical) was found in twenty-five cases. Report of the bacteriology of these abscesses is given in Table I. In four cases local cerebral necrosis was found. In one case there was a compound depressed fracture of the skull without associated intracranial infection. In all cases it held true that lesions manifested by paralysis were in the region of the motor strip or pyramidal tracts. In those cases in which the lesion was manifested only by the signs of increased intracranial pressure, abscesses were in the silent areas of the brain. In two cases in which a visual defect was the only indication for operation, the lesions were found in the occipital lobe.

Postoperative Care.—Therapy with sulfadiazine and penicillin was continued after operation. In addition, the abscess cavities were irrigated every

TABLE I. BACTERIOLOGY OF CEREBRAL ABSCESS SECONDARY TO GUNSHOT WOUNDS OF THE HEAD

ORGANISM	NUMBER OF CASES
Organisms of the proteus group	4
Hemolytic staphylococcus aureus	4
Beta hemolytic streptococcus	2
Nonhemolytic staphylococcus	1
Nonhemolytic streptococcus	1
Anaerobic streptococcus	1
Anaerobic gram-positive rods	1
Gram-positive micrococci	1
Organism not identified	15
Total	30

TABLE II. LATE COMPLICATIONS OF WAR WOUNDS OF THE HEAD (ANALYSIS OF 30 CASES)

CASE NO.	MAJOR INDICATION FOR OPERATION	FINDINGS AT OPERATION	RESULT
1	Hemiplegia, complete	Subcortical abscess with clot, frontoparietal region, left	Ambulatory but with weakness of affected extremities
2	Hemiplegia, complete	Small subcortical abscess, frontoparietal region, left	Complete recovery
3	Hemiplegia, complete	Small subcortical abscess, frontoparietal region, left	Complete recovery
4	Hemiplegia, incomplete	Depressed fracture, epidural abscess, parietal region, left	Complete recovery
5	Hemiplegia, complete, aphasia, semiconscious	Large subcortical abscess, frontoparietal region, left	Ambulatory, aphasia improved
6	Hemiplegia, incomplete	Subcortical abscess, temporoparietal region, left	Ambulatory but with paralysis of lower extremity
7	Hemiplegia, incomplete	Large subcortical abscess with much brain edema, frontoparietal region, left	Return of function of upper extremity; no improvement of lower extremity
8	Hemiplegia, complete	Large subcortical abscess with cerebral edema, frontoparietal region, right	No improvement
9	Hemiplegia, incomplete	Small subcortical abscess, frontoparietal region, left	No improvement
10	Paralysis of both feet	Depressed fracture of the vertex and epidural abscess over the longitudinal sinus	Ambulatory with residual weakness of muscles of left foot
11	Paralysis of both feet	Depressed fracture and epidural abscess over the vertex to the right of longitudinal sinus	Ambulatory with residual weakness of left foot and ankle
12	Blurred disc margins	Small subcortical abscess, frontal lobe, left	Complete recovery
13	Blurred disc margins	Large subcortical abscess, frontal lobe, right	Complete recovery
14	Blurred discs	Small area of necrosis of cerebral cortex, frontal lobe, right	Complete recovery
15	Choked discs	Large subcortical abscess, frontal lobe, right	Complete recovery
16	Bilateral choked discs, seventh nerve paralysis	Large subcortical abscess, frontal lobe, right	Complete recovery
17	Bilateral sixth nerve paralysis, drowsiness	Large subcortical abscess, frontal lobe, left	Recovery, nerve paralysis improved
18	Drowsiness, bilateral choked discs, respiratory depression	Subcortical abscess, parieto-occipital region, right	Complete recovery
19	Unconscious; infected wound	Depressed fracture, epidural abscess, temporoparietal region, left	Regained consciousness; residual mental retardation

TABLE II. (CONT'D)

CASE NO.	MAJOR INDICATION FOR OPERATION	FINDINGS AT OPERATION	RESULT
20	No constitutional or localizing signs; infected wound	Depressed fracture of postparietal region with laceration of dura and brain; indriven bone fragments, brain necrosis, left	Complete recovery
21	No constitutional or localizing signs; infected wound	Depressed fracture of frontal bone with osteomyelitis and epidural abscess, right	Complete recovery
22	No constitutional or localizing signs; infected wound	Depressed fracture, epidural abscess, parietal region, left	Complete recovery
23	No constitutional or localizing signs; infected wound	Depressed fracture, epidural abscess, postparietal region, right	Complete recovery
24	No constitutional or localizing signs; infected wound	Depressed fracture, epidural abscess, parietal region, right	Complete recovery
25	No constitutional or localizing signs; infected wound	Huge depressed fracture of occipital, temporoparietal and frontal bones; epidural abscess, right	Complete recovery
26	No constitutional or localizing signs; infected wound	Depressed fracture, epidural abscess, frontal region, right	Complete recovery
27	Defect of visual red (homonymous)	Necrosis of brain, occipital region, left	No change
28	Partial blindness; convulsive seizures	Small subcortical abscess and epidural abscess, occipital region in midline	Seizures relieved, no improvement in vision
29	Signs of meningitis; paralysis of both lower extremities; semiconscious; aphasic	Depressed fracture, huge subcortical abscess ruptured into lateral ventricle; suppurative meningitis, frontoparietal region, left	Died
30	Generalized convulsive seizures; no localizing signs	Through-and-through wound of both frontal regions; huge abscess, left frontal lobe ruptured into lateral ventricle, suppurative meningitis	Died

two hours through the drainage tube using solution of penicillin (250 units to 1 c.c.). Increased intracranial pressure was relieved by repeated spinal punctures. Fluids were not restricted. Drains were left in place for five days after operation unless there were signs of cortical irritation. In three cases the occurrence of jacksonian epilepsy necessitated the removal of the drain. A detail of great importance is the early institution of physiotherapy to the paralyzed extremities. In some cases electrical stimulation of the affected muscles was used. Patients were encouraged to get out of bed as soon as their general condition and their strength permitted. Occupational therapy and recreational therapy were employed while these soldiers awaited transportation to the United States.

Results Following Operation.—Of particular interest are the clinical results following operative surgery. Five of the nine patients with hemiplegia (Cases 1 to 9) recovered completely from paralysis and two were greatly improved. Only two were unimproved. The two patients in whom there was paralysis of the lower extremities (Cases 10 and 11) recovered sufficiently to walk out of the hospital unassisted by braces. In seven out of eight cases in which operation was performed because of signs of increased intracranial pressure (Cases 12 to 19)

there was complete recovery. The eighth patient (Case 19) recovered physically but mental retardation persisted. Complete recovery followed in seven cases in which surgery was carried out because of infected wounds overlying a depressed fracture (Cases 20 to 26). Two patients in whom the injury was to the occipital lobe (Cases 27 and 28) failed to show improvement. In two patients in whom cerebral abscess had perforated into the lateral ventricle of the brain the patients succumbed despite drainage of the abscess (Cases 29 and 30).

A summary of results following operation for the late sequelae of gunshot wound of the head shows that of these thirty cases, sixteen patients recovered completely, five showed dramatic improvement, three improved, four failed to improve, and two died. In Table II are listed for each individual case the indications for operation, the findings at the operating table, and the results at the time the patients embarked for the United States.

In this brief presentation no attempt is made to discuss each case in detail. Since these cases fall roughly into six groups, exemplary case reports are presented. Cases are numbered according to their sequence in Table II. Cases 1 to 9 are those in which hemiplegia was found in association with abscess of the parietal area of the brain. The following case report is typical of those in this group, with hemiplegia and aphasia due to subcortical abscess of parietal lobe, fungous cerebri, surgical drainage forty-eight days, after injury, wound healing by skin graft, and recovery from paralysis and aphasia.

CASE 5.—This is the case of a 23-year-old, white sergeant in the infantry who was wounded in action Nov. 17, 1944, at Leyte, Philippine Islands. An enemy machine-gun bullet entered the left parietal region of the skull and made its exit through the frontal area. No operative treatment had been given in the forward area. Records indicated that sulfadiazine and penicillin had been given for ten days prior to arrival at this general hospital on Dec. 13, 1944. Examination revealed a semiconscious white man. Temperature was 104° F.; pulse, 116; respirations, 25; blood pressure, 130/80; red blood cells, 1,900,000; white blood cells, 12,000; hemoglobin, 45 per cent. The patient responded to simple commands. The small scar of the healed wound of entry was over the left parieto-occipital region. Beta hemolytic staphylococcus was recovered on culture of thick yellow pus which drained from the wound. The photograph (Fig. 3) demonstrates that the machine-gun bullet entered the left parieto-occipital region, traversed the left cerebral hemisphere, and made its exit from the skull in the left frontal region. Through this wound necrotic, pulsating, cerebral tissue protruded. Roentgenograms (Fig. 4) demonstrated the extensive bursting type of fracture of the left occipital, parietal, and frontal bones. The heart and lungs were normal. There was some abdominal distention. Neurologic examination revealed cervical rigidity. The patient was completely aphasic. There was paralysis of the right facial nerve (central type). Vision could not be tested satisfactorily. Right hemiplegia was manifested by flaccid paralysis of the right upper extremity and spasticity with weakness of the right lower extremity. Reflexes were hyperactive on both sides. Sustained ankle clonus and Babinski reflexes were elicited bilaterally. Spinal tap done at the time of admission revealed normal spinal fluid not under increased pressure. The patient was treated with intravenous fluids, transfusions of blood, and penicillin intramuscularly and intrathecally. There was gradual improvement in the general condition though he remained in a semiconscious state. An abscess of the scalp developed in the left frontal region. This was incised and drained. A few days later the patient had a generalized convulsive seizure followed by copious drainage of pus from the wound of the left frontal region. The patient's general condition again improved. At operation on January 5 (forty-eight days after injury) the wound of exit was excised and several large fragments of bone were removed. The necrotic cerebral tissue was removed from the frontal

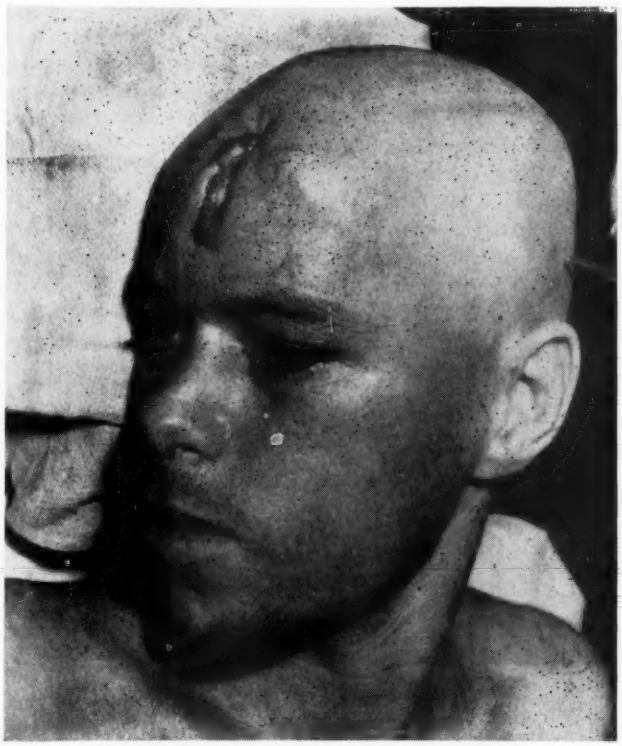
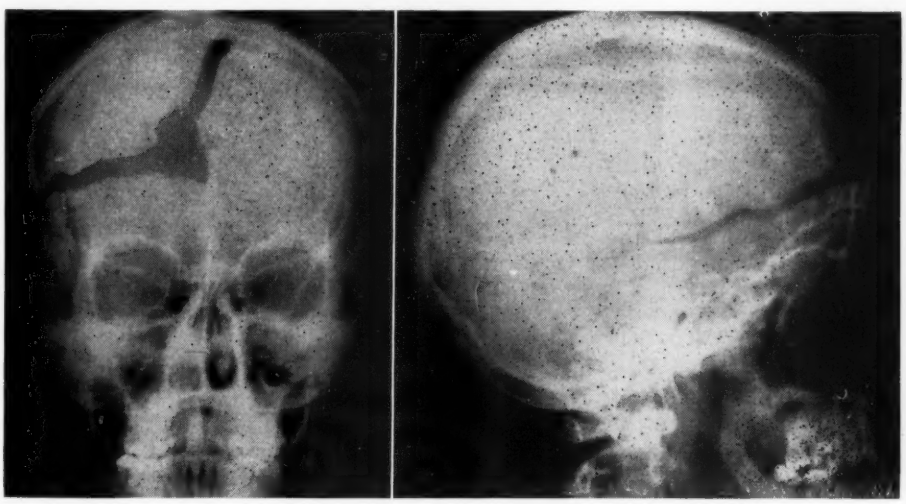


Fig. 3 (Case 5).—In this photograph the hemostat points to the scar which represents the healed point of entry of the bullet. Progressing anteromedially the bullet made its exit from the site of fungous cerebri in the left frontal region. The patient had complete right hemiplegia which was accounted for by the finding of a large abscess directly under the motor strip and in the path of the bullet. He recovered from hemiplegia.



A. *B.*

Fig. 4 (Case 5).—Anteroposterior and lateral views of skull showing the extensive and elevated fracture. This had been caused by an enemy machine-gun bullet which entered the left parieto-occipital area and made its exit from the skull in the left frontal region.

lobe using the electrosurgical unit. The tract of the missile was probed and a large subcortical abscess was encountered directly under the motor strip. The cavity was irrigated with penicillin and the wound of the scalp was closed loosely about a soft rubber tube which extended into the abscess. After operation the patient regained consciousness and the general condition improved rapidly. For the first few days after operation the abscess was irrigated every two hours with penicillin solution (250 units per cubic centimeter). The hemiplegia diminished and on the twenty-fifth day after operaton the patient was able to walk with assistance. A thick split graft was applied to the wound of the forehead on February 25. The patient regained motor control of the extremities. The facial paralysis diminished. Speech returned slowly. In the postoperative care of this patient intensive physical therapy was given to affected muscles and speech training was emphasized. At the time of evacuation to the United States on March 8, 1945, he could talk in simple phrases and walked about without assistance.

There were two patients (Cases 10 and 11) in whom there was paralysis of the lower extremities due to depressed fracture in the region of the vertex of the skull, with epidural abscesses overlying the longitudinal sinus and the upper portion of the motor strips on both sides. Both of these patients recovered from paralysis following elevation of the fracture and simple drainage of the abscesses. An exemplary case record follows, in which there were paralysis of both feet due to depressed fracture over the vertex of the skull with epidural abscess, surgical drainage ten days after injury, complete healing of the wound, and recovery from paralysis.

Fig. 5 (Case 10).—Lateral x-ray view of skull showing fracture caused by tangential impact of an artillery shell fragment. In this case an epidural abscess had formed over the longitudinal sinus. The wounds of entry and exit were confluent over the vertex of the skull.

CASE 10.—This 19-year-old paratrooper was wounded in action by an artillery shell fragment on Oct. 20, 1944, at Leyte, Philippine Islands. No operative treatment was given in the forward area. The patient was evacuated by L.S.T. and arrived at this hospital on October 28. Penicillin had been given intramuscularly while en route. Examination revealed a well-developed, malnourished, pale, white man who was conscious and mentally alert. Temperature was 99° F.; pulse, 85; respirations, 18; blood pressure, 120/80; red blood cells, 3,000,000; white blood cells, 10,000; and hemoglobin, 60 per cent. The heart, lungs, and abdomen were normal. Examination of the head revealed a dirty, infected wound over the vertex of the skull through which a depressed fracture of the skull could be seen. The furrowed wounds of entry and exit were confluent. Apparently the fracture of the skull had been caused

by tangential impact from the missile. Neurologic examination revealed that there was no disturbance of function of the cranial nerves. Sensory examination was normal except for hypesthesia over the right foot and hypesthesia of the left foot extending up to the middle third of the left leg. There was paralysis of both feet. Babinski reflexes were present on both sides. The patellar and Achilles reflexes were hyperactive on both sides. There was sustained ankle clonus on the right. Neurologic examination was otherwise normal. Roentgenograms showed a depressed, comminuted fracture directly over the median sagittal suture of the skull. There were no retained foreign bodies. Photograph of lateral x-ray view of the skull is shown in Fig. 5. Transfusions of blood were given and therapy with penicillin was continued. At operation on Oct. 30, 1944, ten days after injury, the infected wound was excised and the depressed fractures of the two parietal bones, near the medial sagittal line of the skull were exposed. Depressed fragments of bone were removed. There was an epidural abscess overlying the longitudinal sinus. The dura mater had not been penetrated. The epidural space was protected from the abscess by thin strips of iodoform gauze packing and the wound of the scalp was closed about a soft rubber tube. Hemolytic *Staphylococcus aureus* was recovered on culture of the purulent exudate. Postoperatively the wound was irrigated every two hours with penicillin solution (250 units per cubic centimeter). The iodoform gauze packs were removed on the fourth postoperative day and the tube was removed on the fifth day. The wound healed by second intention. The paralysis of the feet gradually diminished and the patient was able to walk on December 5. Muscle training was instituted and the patient embarked for the United States on December 16. At that time he walked unassisted. There was residual weakness of the tibialis anticus group of muscles on the left and paresis of the plantar flexors on the right.

In eight patients (Cases 12 to 19) the clinical pictures were similar in that the significant physical signs referable to increased intracranial pressure were the findings on ophthalmologic examination. In these cases the areas of cerebral necrosis or abscess were located either in the frontal or in the occipital lobes. In three of these patients there were signs (other than choked discs) of increased intracranial pressure. Clinicians were impressed with the fact that in several cases in which large abscesses were encountered, the presence of blurring of the optic fundi was the sole clinical sign which indicated that an intracranial lesion existed. Of the eight patients in this group, seven recovered completely following operation. The case history of one of these patients follows, showing drowsiness, respiratory depression and choked discs due to subcortical abscess in the parieto-occipital region; surgical drainage fifteen days after injury; and complete recovery.

Case 18.—This 19-year-old white infantryman was wounded by fragments of a hand grenade on Dec. 10, 1944, at Leyte, Philippine Islands. He was transported to Hollandia, New Guinea, by hospital ship arriving December 24. There had been no operative surgical treatment. Penicillin had been given for eight days prior to admission to this general hospital. He was ambulatory but complained of left parietal headache. Temperature was 99.8° F.; pulse, 60; respirations, 20; blood pressure, 130/85; red blood cells, 3,500,000; white blood cells, 12,500; hemoglobin, 80 per cent. There was an infected wound with draining sinus over the right parietal region of the scalp. X-ray examination revealed a perforated fracture of the skull in the right occipital area, a cluster of small comminuted fragments of bone in the occipital region of the right cerebral hemisphere, and a metallic foreign body (1 cm. in diameter) in the substance of the brain in the left parieto-occipital area. Within sixteen hours after admission, this patient became increasingly drowsy. The pulse rate dropped to 54 and the respirations to 12 per minute. Spinal fluid pressure was 220 mm. Dynamics were normal and the fluid was clear. Neurologic examination was negative save for the findings on ophthalmologic examination. Both optic discs were choked. Based on experience with earlier cases the abscess was presumed to be in the right occipital lobe centered

about the indriven chips of bone rather than on the opposite side where a metallic fragment had lodged. On December 25 (fifteen days after injury) the wound of entrance over the right parieto-occipital area was excised and a circular section of skull surrounding the perforation was removed. The typical papilla-like projection, composed of granulation tissue, clotted blood, debris, necrotic brain and hair, projected from the torn dura mater to plug the perforation in it and in the skull. The dura mater about the papilla was excised. The epidural and subdural spaces were sealed with the electrosurgical unit. Thirty cubic centimeters of thick, yellow pus were evacuated from an abscess deep in the subcortical area of the right occipital lobe. Hemolytic staphylococcus was recovered on culture of this pus. Along with the pus, numerous small fragments of bone were removed from the wall of the abscess. The operative findings were typical of the cases in which cerebral abscess develops after injury by a missile. Apparently the missile perforated the skull carrying before it a cluster of bony particles which lodged in the path of the metallic fragment at a depth of 2 to 3 cm. below the cerebral cortex. The missile progressed onward, coming to rest in the opposite cerebral hemisphere or making its exit from the skull, depending upon the force of its unspent momentum. In this case the abscess cavity was unroofed and the wound was irrigated with penicillin solution. The scalp was sutured loosely about a soft rubber tube.

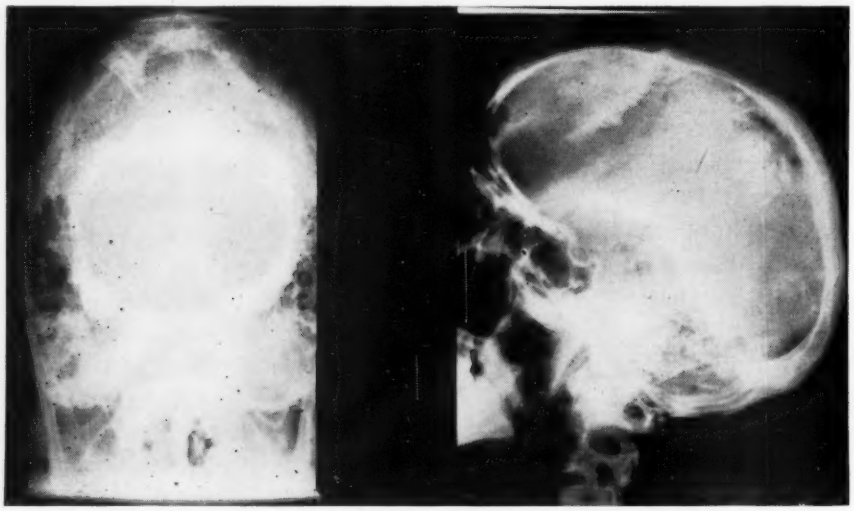


Fig. 6.—Front and side views of skull showing indriven fragments of bone about which a subcortical abscess was centered.

As soon as the pus had been evacuated the patient became talkative and stated that the headache had been relieved. Postoperative therapy was carried out (as in Cases 5 and 10 reported previously). The patient made an uneventful recovery. The optic fundi were normal and vision was unimpaired at the time of embarkation to the United States on the thirtieth day after injury.

Cases 20 to 26 comprised a group of cases in which, in the absence of neurologic or localizing signs, surgical exploration was necessary because of infected wounds overlying depressed skull fractures. Findings at operation in these seven cases were as follows: epidural abscess, five cases; epidural abscess with osteomyelitis of the skull, one case; cerebral necrosis about indriven fragments of bone, one case. All of these patients made an uneventful recovery following excision of the chronically infected wounds, elevation of the depressed fractures, and irrigation of the wound with penicillin. A case report representa-

tive of the group, with depressed skull fracture without localizing signs but with large infected wound and extradural abscess, follows:

CASE 25.—This 21-year-old infantryman was wounded in action by an enemy shell fragment Feb. 10, 1945, at Luzon, Philippine Islands. There was no primary operative treatment. The patient was transported to Hollandia, New Guinea, via hospital ship, arriving at this general hospital Feb. 25, 1945. The patient was ambulatory and felt quite well. Temperature, pulse, and respirations were normal. Physical examination revealed nothing of importance save the wound of the head. There was an infected, granulating wound of the right parieto-occipital region. The wound measured 6 by 3 cm. Its surface was covered with a dry crust under which there was necrotic soft tissue. A depressed fracture was found on exploration with a blunt instrument. Apparently this ovoid wound represented the confluent points of entry and exit of a missile which had struck the skull tangentially. X-ray examination revealed an extensively comminuted, depressed fracture involving the frontal, parietal, and temporal bones. At operation on Feb. 27 (seventeen days after injury) it was revealed that despite the extent of this depressed fracture, the dura had not been lacerated. There was a large extradural collection of pus and granulation tissue. All depressed fragments of bone were removed. The wound was sutured loosely over a soft rubber tube through which irrigation with a solution of penicillin was carried out. The tube was removed on the fifth day after operation. The patient made an uneventful convalescence and embarked for the United States on March 8, 1945.

Observation of the thirty patients included in this report has established the impression that cerebral infection following war wounds of the head tends to localize, often forming an abscess about the indriven fragments of bone. Experience with this small group of cases does not warrant conclusions as to whether or not therapy with sulfonamide drugs and penicillin favors this localization. Cases 29 and 30 bring attention to the fact that although cerebral abscesses due to missile wounds tend to localize, it does not follow that these abscesses will remain limited in size. These two cases are discussed together because both are examples of fatality due to rupture of cerebral abscess into the lateral ventricle. The relatively slow development of abscess following war wounds of the head may allow for firm healing of wounds of scalp and skull before the pressure within the abscess reaches its highest point. Consequently, rupture into the lateral ventricle may be expected in neglected cases. The following case report is given as an example, with meningitis due to rupture of a subcortical cerebral abscess into the lateral ventricle; death.

CASE 29.—This 25-year-old private of the engineering corps was wounded by a shell fragment on Feb. 6, 1945, in Luzon, Philippine Islands. Débridement of the skull and scalp with primary suture was done at an evacuation hospital eight hours after injury. The patient was admitted to this hospital in critical condition on March 28. He was semiconscious and febrile. There was marked cervical rigidity. Temperature was 100° F.; pulse, 88; respirations, 18; blood pressure, 120/85; red blood cells, 3,000,000; white blood cells, 16,000; hemoglobin, 62 per cent. Through a defect of the skull and scalp in the left parieto-frontal region, necrotic brain fungus presented. There was paralysis of the seventh nerve on the right side (central type) and there was divergent squint. There was flaccid paralysis of both lower extremities and urine was overflowing from the distended bladder. Spinal fluid was cloudy and the pressure was 180 mm.. Roentgenograms showed a defect of the skull in the left parietal region. Treatment at first was by means of supportive measures. Penicillin was given intrathecally. The clinical records were inadequate but it was apparent from the surgeon's note that débridement of the scalp and skull had been carried out but that the meninges and brain had not been disturbed at the primary operation. When, therefore, five

days after admission to this hospital, the cervical rigidity was diminishing and the patient was slightly improved, surgical exploration was advised. It was reasoned that the signs of meningitis might have been due to extension of an abscess toward the pia-arachnoid and that drainage of such an abscess offered the best hope for recovery. At operation on March 29 (fifty-one days after injury) a large subcortical abscess of the left frontoparietal area was drained. The abscess extended into the lateral ventricle. Copious amounts of thin purulent material were evacuated. Suppurative ependymitis and meningitis were in evidence. After operation the signs of meningitis persisted and the patient died on March 31. Post-mortem revealed that the abscess cavity was 8 cm. in greatest diameter. It was oblong in shape and occupied a position extending into the subcortical areas of the frontal, parietal, and temporal areas of the cerebral hemisphere. It had eroded or compressed most of the tissue of the cerebral hemisphere and had ruptured into the anterior horn of the ventricle. There was cellular infiltration of the entire left cerebral hemisphere and generalized suppuration of the meninges.

SUMMARY AND COMMENT

An analysis is presented of thirty cases of missile injury to the head in which neurosurgical exploration was not carried out until eight to fifty-one days after injury. There were twenty-seven cases of intracranial abscess. Ten of these were extradural abscesses while seventeen were cortical or subcortical. In three cases of depressed fracture there was laceration of meninges and brain. Regional paralysis, together with x-ray evidence of depressed fragments, has served to make localization of these abscesses relatively easy. Commonly the point of entry of the missile is marked by an infected wound. Invariably the abscess is centered about the dislocated fragments of bone, not around the missile. The metallic foreign body often is at a distant site in the cranial cavity or may have made its exit from the skull. Persistent or progressive paralysis, wound infection, or findings on ophthalmologic examination have presented the indications for operation. Of these thirty patients who developed complications which were the sequelae of infection of war wounds of the head, twenty-eight survived operation. Following primary operation performed many days after injury, sixteen patients recovered completely, five showed dramatic improvement, three improved, four failed to show improvement, and two died. The mortality rate in this series of cases is 6.6 per cent.

AFFERENT CONDUCTION VIA THE SYMPATHETIC GANGLIA INNERVATING THE EXTREMITIES

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WHILE there is a general denial that afferent sensations are transported via the sympathetic innervation of the extremities, experiments conducted for the purpose of establishing the existence of such pathways continue to be of great interest. A physiologic demonstration of afferency within the gray rami communicantes and the sympathetic ganglia innervating the extremities will eliminate much of the confusion which exists in our knowledge of pain conduction.

This paper deals with afferent conduction in the spinal nerve below the gray rami communicantes to the cord in the region of the lumbosacral plexus.

REVIEW

Ransom and Billingsley[1] have described both myelinated and unmyelinated fibers in the gray rami communicantes of the cat. Kuntz and Farnsworth,[2] studying the sympathetic trunks and gray rami communicantes in the cat, stated that certain fibers in these structures supplying the extremities must be regarded as afferent from an anatomic standpoint.

Moore and Singleton[3] showed that the arterial injection of lactic acid is intensely painful to animals after a sympathectomy, and the majority of workers feel that sympathetic ganglionectomy does not interfere with afferent sensations. Since Moore and Singleton also were able to show that there is no painful response following section of the peripheral nerve to the part, the conclusion was drawn that the blood vessels receive their sensory supply from the peripheral nerves and not from the sympathetic nerves per se.

The present concept of vascular innervation of the extremities is based on the results of this work and is as follows: All the vessels and pilosebaceous apparatus of the extremities receive innervation from the peripheral nerves with efferent fibers only from the sympathetic ganglia. These fibers enter the peripheral spinal nerves by way of the gray rami communicantes. Consequently, the explanation of the relief of pain, in a human being, following sympathectomy is that vascular spasm is relieved by sympathetic interruption.

de Takats,[4] however, demonstrated that in many cases of causalgia there is no vasospasm, but rather there is vasodilatation. In the presence of vasodilatation, the benefit obtained by sympathectomy cannot be explained on the basis of the concept stated previously.

Livingston's[5] theory of internunciary neurons within the spinal cord is generally accepted as the explanation of the good results which follow sympathetic interruption, although actually the procedure remains on an empirical

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basis. My experiments, I believe, tend to provide a more satisfactory explanation of the relief of pain afforded by sympathectomy, and, in addition, show that certain afferent impulses from the extremities are blocked by sympathetic ganglionectomy.

There are visceral reflexes in the abdominal viscera which certainly are completed without reaching the spinal cord,[6] but there is little evidence, up to the present, that similar reflexes of the extremities are completed outside the cord. Most anatomists find such a concept untenable because of the absence of actual and separate sympathetic nerves to the vessels and pilosebaceous apparatus of the extremities.

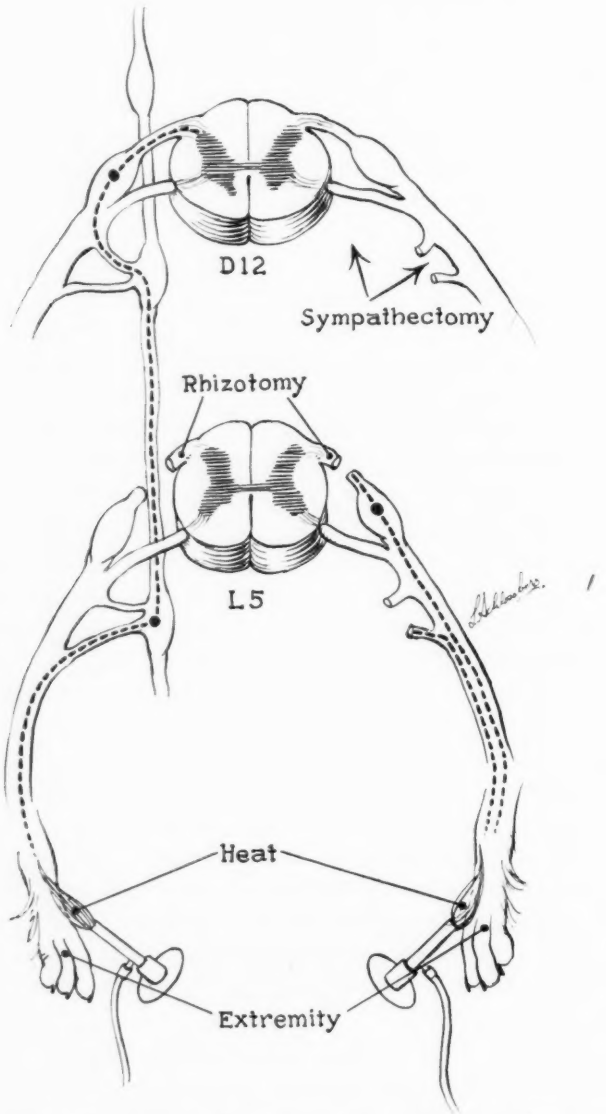

Fig. 1 (Preparation 1).—Showing bilateral posterior rhizotomy of nerve root to leg with unilateral sympathetic ganglionectomy. Painful sensations from heat are manifested by reaction on the nonsympathectomized side only. The anterior roots are undamaged.

Dogiel,[7] in 1896, showed that both motor and sensory nerve cells are present in the stellate ganglia of dogs, and he believed that visceral reflexes are completed in the sympathetic ganglia.

Foerster and Gagel[8] maintained that pain impulses may travel by way of the sympathetic ganglionic chain and enter the cord through extrasegmental levels. Like Le Riche and Fontaine,[9] they believed that these impulses were carried to the ganglia via the perivascular plexii.

Since all sensation from the extremities travels by way of the peripheral nerves[10] and since sympathetic ganglionectomy relieves pain in many cases, including those of vasodilatation, the assumption that at least part of the sensory impulses are relayed to the sympathetic ganglia on their way to the cord is justified.

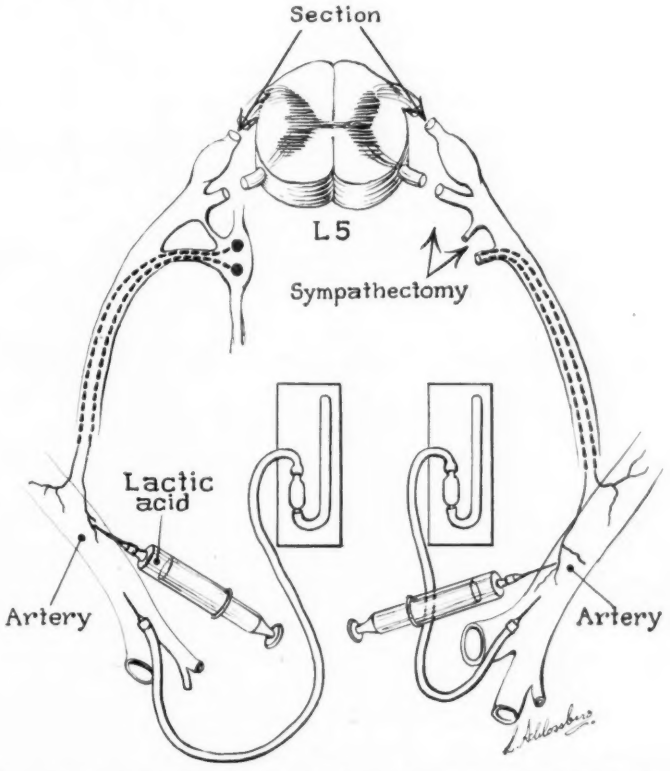

Fig. 2 (Preparation 2).—Showing bilateral section of both anterior and posterior nerve root with unilateral sympathetic ganglionectomy. Lactic acid injection of artery of leg shows blood pressure changes on nonsympathectomized side only.

EXPERIMENTAL OBSERVATIONS

In order to substantiate such an assumption, a preparation was made as is shown in Fig. 1. Following a preliminary removal of the sympathetic ganglia innervating one lower extremity, a bilateral posterior root section was performed to the extent that no further painful responses were elicited on the sympathectomized side. Since identical painful stimulation of the nonsympathectomized side produced a response manifested by kicking, one may believe

that at least a portion of painful sensation travels by way of the sympathetic ganglia and enters the cord through extrasegmental levels. The possibility that sensation had entered the cord via the anterior root was recognized and a second preparation, as is shown in Fig. 2, was made in order to prove this had not happened.

For this preparation unilateral sympathectomy was performed and bilateral section of both the anterior and the posterior root was done and was sufficiently extensive to eliminate response, on the sympathectomized side, to the stimulation produced by the injection of lactic acid into an artery. Since the anterior roots were sectioned, response was necessarily demonstrated by blood pressure variations rather than by kicking or other motion. The use of lactic acid as a means of stimulation on the nonsympathectomized side, however, produced immediately a sudden and marked fall in the blood pressure. This result demonstrated that vascular reflex response may be completed entirely outside the cord, because with both anterior and posterior roots severed, there was no possibility that afferent sensations had entered the cord by these routes.

Methods.—Through the courtesy of the Georgetown University Department of Pharmacology, experiments were conducted on dogs in the laboratory of pharmacology during the winter and spring of 1946.

Dog 1.—This dog was used as a preliminary experiment. Under nembutal and ether anesthesia a left sympathectomy, equally as extensive as the succeeding ones, was performed using an anterior retroperitoneal approach. The incision was closed and the animal was allowed to recover. Ten days later this animal (a 4-month-old dog) was operated upon, in the prone position under nembutal and ether anesthesia, and the spinal cord was severed at the first lumbar. The foot pads were then stimulated with flame and the left (sympathectomized) side was observed to react whereas the right side did not.

Dog 2.—Under ether anesthesia the left sympathetic ganglionic chain was removed, through a lumbar extraperitoneal approach, from the first lumbar sympathetic ganglion to its conclusion. A laminectomy was then performed from the second lumbar vertebra through the anterior one-half of the sacral plate. The dura was opened to expose the cord, and the posterior roots of the fourth lumbar to the third sacral were then sectioned bilaterally, at the point where all filaments were united. Immediately on completion of the operation, stimulation (flame of a Bunsen burner) was applied to the foot pads of the animal. The right leg reacted at once with a moderate kicking motion. The left leg did not react at all.

Dog 3.—The experiment used on Dog 2 was repeated and the same result was obtained.

Dog 4.—Under ether anesthesia a left lumbar sympathectomy was done and the cord was exposed in the same manner as in Dog 2. Both anterior and posterior nerve roots, beginning with the first sacral and proceeding caudad and cephalad, were sectioned until no further twitching of the legs occurred (section included nerve roots from the fourth lumbar through the third sacral). The left femoral artery was then exposed, just above the knee, and a cannula, pointing toward the heart, was placed in the artery. The artery was clamped distal to the cannula. As soon as a preliminary recording of the blood pressure was made on the kymograph, 10 c.c. of a 10 per cent solution of lactic acid were injected rapidly into the artery, below the recording cannula and clamp (so that the injection could not directly affect the pressure). The solution entered the artery in the direction of the normal blood flow. No change was noted in the blood pressure during a fifteen-second observation period.

Next the right femoral artery was exposed, cannulated in the same manner, and 10 c.c. of a 10 per cent solution of lactic acid were injected, below the cannula, into the artery.

Within one second the blood pressure dropped as shown in Fig. 3. The blood pressure then began to rise evenly and in fifteen seconds it had returned to the base level. The animal was then destroyed.

The reaction of Dog 1 supported the observations made by Wolf and Hardy[11] that following a sympathectomy an extremity, not otherwise damaged neurologically, reacts more sensitively to thermal changes. A reasonable explanation of this occurrence, which will be alluded to again, is that changes in the sympathetic afferents (which must be largely C fibers)[12] render the remaining central afferent fibers more sensitive to pain. It is interesting to conjecture that this increased sensitivity may account for the intractable pain of certain causalgic states, which have obviously diseased sympathetically innervated organs. Such phenomena are in contrast to the condition seen in Raynaud's disease in which sympathectomy produces relief of vessel spasm.

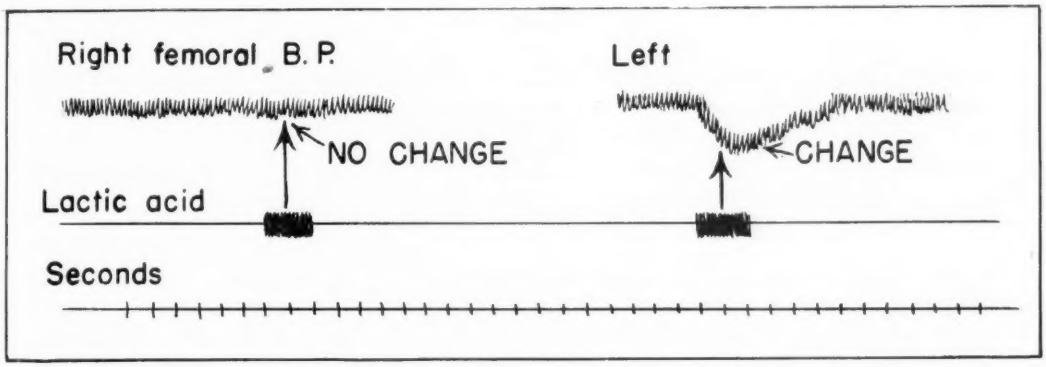

Fig. 3 (Preparation 2).—Showing blood pressure changes following lactic acid injection in the right or nonsympathectomized femoral artery. No change occurred on the left (sympathectomized) side.

COMMENT

Sympathetic afferents from the extremities are probably similar in function to the viscerosensory fibers in the splanchnic trunks. The location of the cell body, however, will be discussed in a future article.

These present experiments indicate that blocking of the sympathetic nerves can be placed on a sound anatomic and physiologic basis because, in addition to efferent fibers being interrupted, afferent fibers are interrupted.

The relief of pain afforded clinically by paravertebral ganglionic block and/or sympathectomy in certain morbid processes may be due to the relief of vasospasm or the blocking of afferent impulses from the vessels and pilosebaceous apparatus of the extremities, or both.

It is probable that afferent impulses from involuntary structures pass primarily to the sympathetic ganglia for integration with the sympathetic efferents, before entering the cord. In early morbid states, this same mechanism produces the pain which can be relieved by sympathectomy. However, with the progression of morbidity, the central spinal nerves appear to be affected, and this central nerve involvement accounts for the poor results obtained from sympathetic interruption in cases of fixed causalgic lesions.[13]

SUMMARY

1. By means of rhizotomy and unilateral sympathectomy on experimental animals, painful sensations are shown to enter the cord by way of the sympathetic ganglia.

2. After sectioning both anterior and posterior nerve roots in animals with unilateral sympathectomy, arterial reflex response is shown to occur on the non-sympathectomized side following lactic acid stimulation. Such experiments prove that vascular reflex response in the extremities may be completed entirely outside the cord.

3. Afferent sensation via the sympathetic ganglia of the extremities aids in explaining the confusing results of sympathectomy and other surgical attacks on the nervous system for the purpose of relieving pain.

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SURGICAL MANAGEMENT OF VASCULAR LEG ULCERS

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ULCERS of the lower extremity are primarily surgical cases. Too often surgery is thought of only after the patient has been given long periods of local treatment. Too much is expected of local treatment, one form of medication after another being tried before surgery is suggested.

After more than ten years' experience with such cases in the Peripheral Vascular Clinic of The Grace Hospital, we are convinced that the surgical approach to peripheral vascular ulcers not only shortens the period of treatment but also, in many cases, offers the only chance for a lasting cure.

A proper appreciation of the etiology of leg ulcers demonstrates why this assertion is correct. Although such ulcers may be divided into ischemic, due to occlusive arterial disease, and varicose, when venous congestion is the cause, yet the local effects are quite similar. In both types of ulcer there are local malnutrition and lowered tissue resistance. When an ulcer forms in tissue with impaired blood supply, the natural healing powers are diminished, and the ulcer tends to persist. If it does heal it is prone to recur as long as the original cause of stasis or ischemia remains uncorrected. This oversimplification of the pathology of indolent ulcers serves to emphasize the fact that the cause of the ulcer must be removed if a permanent cure is to be effected. It is beyond the scope of this paper to consider in detail the pathology of indolent ulcers. The reader is referred to a recent article by Heller[1] for an excellent pathologic description.

A frequent error is to treat the ulcer and forget its owner. The proper management of these cases requires a complete and careful history and physical examination, including a blood count, urinalysis, and blood serology. Other laboratory work and special examinations should be done when indicated.

In taking the history, special attention should be given to such matters as pain upon use of the limb, numbness and coldness of the toes, discoloration of the skin, a history of thrombosis, and frequency of recurrence of ulceration. Answers to these queries may lead to the diagnosis of other vascular diseases such as Buerger's or Raynaud's disease or arteriosclerosis.

In the local examination of the extremity, the examiner should observe skin changes, evidence of venous stasis, the character of the pulse in the dorsalis pedis, posterior tibial, popliteal, and femoral arteries. If veins are observed, the Trendelenburg and Perthes tests should be done. An attempt should be made to elicit Homans' sign.

Fluorescein Dye Tests.—Skin temperature tests and fluorescein dye tests are especially helpful in those cases where ischemia and stasis appear together, as well as to determine the condition of circulation in the skin around the ulcer

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site. We have found the fluorescein dye test as dependable as either skin temperature or oscillometric determinations. Also, it gives more accurate information as to the level of arterial involvement and the character of capillary circulation in the skin.

Ten cubic centimeters of a 5 per cent intravenous solution of fluorescein dye and a mercury lamp make up the special equipment for this test.[2] The lamp has a glass filter which excludes most of the light rays and transmits light only in the region of 3,600 angstrom units. The dye is slowly injected intravenously. In fifteen to twenty seconds, depending on the speed of the patient's circulation, all areas exposed to the lamp rays where the circulation is good will show an intense golden green hue. It becomes more intense as more of the dye diffuses from the capillaries into the tissues. Cross scratches on the leg make fluorescent lines showing levels to which good circulation travels. Tissue with poor circulation shows as a dark purple color contrast.

In our opinion there are very few contraindications to surgery in ulcer cases. Age is certainly not one of them. We have operated successfully on a number of patients over the age of 70 years and on a few past 80. If concomitant constitutional disease such as diabetes, tuberculosis, or decompensated cardiac disease is found, we delay surgery until these diseases are in check. Otherwise they are treated much the same as any other patient. We do not operate in the presence of serious infection, anemia, or malnutrition. We believe that surgery usually should not be done during pregnancy.

Local Treatment as an Adjunct.—Since most leg ulcers are infected, local treatment must be instituted before surgical procedures are possible. Local treatment has only three purposes: to relieve pain, to combat infection, and to relieve congestion and thereby promote healing. While local treatment will not eradicate the cause of ulceration, it is a necessary adjunct to surgical management, especially to clear up an infected ulcer so that surgical procedures can be used.

Infection is usually due to low-grade staphylococci, streptococci, *Bacillus subtilis,* aerobic spore formers, and epidermophytids. To overcome these infectious organisms we have found that a solution of gentian violet painted on the ulcer combined with a light dusting with sulfathiazole crystals cleans up the ulcer faster than any other method we have tried. Gentian violet has been proved by Holmes and Wilson[3] to be bacteriostatic to the group of organisms mentioned previously as being the usual infective agents.

One of us[4] in 1940 first advocated the local use of sulfonamide drugs in this type of ulcer. Our clinical experience during the past seven years has confirmed our opinion of the value of this combination in infected ulcers.

We cannot agree with those who condemn the local use of sulfonamide compounds in such infections. The recent reports of More[5] and Meleney[6] confirm our belief. In ulcer cases especially, the systemic use of this drug is not as efficacious as its local application because the local blood supply is impaired. We restrict the use of sulfathiazole to infected ulcers and discontinue local applications as soon as infection has subsided. Posch and associates,[7] in experimental studies at Wayne University, established that sulfonamide drugs are

local irritants to the dermis and subcutis but stated that such undesirable effects can be minimized by the use of small amounts of the drug in microcrystalline form. We too have observed that the prolonged use of the drug inhibits epithelization.*

Pressure Dressings.—When stasis is present in the leg, as it usually is in such ulcers, its control by Unna's paste boot, cotton elastic bandage, elastoplast, or some other form of pressure dressing is essential to promote healing. McPheeters[8] was among the first in this country to advocate the use of a rubber sponge with a cotton elastic bandage for this purpose. We have modified his method somewhat by using a soft sponge rubber one-half inch thick in place of the commercial rubber bath sponge. Sponge rubber can be purchased by the yard and cut to fit the size ulcer being treated. Used with the cotton elastic bandage, it supplies constant pressure to the ulcer, exerts a gentle stimulation to the ulcer bed, improves the circulation, prevents venous stagnation, and absorbs the exudate. When pruritis is a factor, x-ray exposure to the back by the technique used in lichen planus, gives gratifying relief by its effect on the sympathetic nerves.

Tables I and II serve to demonstrate the value of pressure dressings in hastening the healing of leg ulcers. The local treatment consisted of the application of gentian violet solution and sulfathiazole crystals. In the varicose type, vein ligations were done routinely.

This series is too small to warrant conclusions as to the comparative value of Unna's boots and sponge rubber as pressure dressings. However, it should be noted that in five instances sponge rubber dressings effected healing after adequate trials with Unna's boots had failed. In two cases where sponge rubber failed, deep phlebothrombosis was present requiring femoral vein ligation.

The principal advantages of sponge rubber over Unna's paste boot are its ease of application, saving of time, and its absorptive powers. Thus, it lends itself to office practice where time is so often a deciding factor in the choice of dressings. Moreover, unless Unna's boots are skillfully and accurately applied they are not only useless but detrimental to the patient. Very little skill is required to fit and apply the sponge rubber dressing.

In varicose ulcers, which are by far the most numerous type encountered, the underlying cause is the varix that feeds them. Therefore, we believe that as soon as infection in the ulcer is under control, ligation of all varicosities should be done. To us this means that the greater saphenous vein and all branches found near the fossa ovalis must be separately ligated, and that all "blowouts" in the thigh or leg should likewise be ligated.

Usually following such ligation and subsequent injection of any remaining varicosities with sclerosing solution, the ulcer shows marked improvement. If after these procedures have been properly done, the ulcer persists, a careful

*Since submission of this article for publication, we have been using a new soluble dressing containing a nitrofuran compound in the local treatment of infected ulcers. This dressing is bactericidal and bacteriostatic to most skin organisms even in high dilutions. It is relatively nonirritating and does not retard tissue repair. Therefore, we believe it is an improvement over the local use of sulfonamides.

TABLE I. UNNA'S BOOT PRESSURE DRESSING

CASE	AGE (IN YR.)	SIZE OF ULCER (IN CM.)	WEEKS OF TREATMENT	TYPE OF ULCER	RESULTS	REMARKS
W. F.	64	$1 \times 1\frac{1}{2}$ 3×3	4	Varicose	Healed	
B. S.	69	$\frac{1}{2} \times 1$	3	Ischemic and varicose	Healed	Recurrence in 2 months
H. T.	79	5×8	20	Ischemic	Healed	Recurrence in 6 weeks, then treated with sponge rubber with complete healing in 6 weeks
J. E.	55	2×3	12	Varicose	Healed	Ulcer recurred 3 times in 6 years; next recurrence should have skin graft
H. L.	51	2×3	16	Varicose	Slight improvement	Is a controlled diabetic; healed in 3 weeks with sponge rubber dressings
K. M.	42	3×4	125	Varicose	Slight improvement	Healed in 9 weeks with sponge rubber dressings
C. W.	81	1×2	24	Ischemic	No improvement	Healed in 6 weeks with sponge rubber dressings
L. S.	58	$1 \times 5\frac{1}{2}$	15	Varicose	No improvement	Healed in 8 weeks with sponge rubber dressings
J. P.	52	2×3	6	Varicose	Healed	
A. B.	54	2×4	8	Varicose	Healed	
V. R.	42	$1 \times 2\frac{1}{2}$	4	Varicose	Healed	
L. A.	69	3×4	12	Ischemic and varicose	Healed	
L. C.	48	1×2	4	Varicose	Healed	
B. F.	55	$1\frac{1}{2} \times 3$	7	Varicose	Healed	
B. B.	51	2×2	6	Varicose	Healed	
F. C.	45	$2 \times 2\frac{1}{2}$	8	Varicose	Healed	
E. G.	43	$1\frac{1}{2} \times 2$	6	Varicose	Healed	
C. L.	44	2×2	6	Varicose	Healed	

investigation of the area about the ulcer must be made. It may be found that some degree of arterio- or arteriolar sclerosis exists. Skin temperature and fluorescein dye tests are helpful in this determination. Or the ulcer may be situated over a pool of varicosities into which an incompetent perforating branch from the deep system is feeding deoxygenated blood. In some cases scar tissue surrounds the ulcer and interferes with the blood supply. Most often the cause of nonhealing of the ulcer in the face of adequate treatment of the associated varicosities will be found in the poor type of epithelial tissue being formed from the ulcer margins.

Plastic Operations.—In cases where arteriosclerosis and venous stagnation are both present physiotherapy is of benefit. Where "blowouts" occur under the ulcer bed and where dense scar tissue surrounds the ulcer area, we resort to plastic operations on the ulcer. For this we employ a modification of the Kondoleon operation. An elliptical incision is made around the ulcer including within the ellipse the scar tissue. The incision is carried down to the deep

TABLE II. SPONGE RUBBER PRESSURE DRESSINGS

CASE	AGE (IN YR.)	SIZE OF ULCER (IN CM.)	WEEKS OF TREATMENT	TYPE OF ULCER	RESULTS	REMARKS
L. K.	64	1 × 1½	4	Varicose	Healed	
H. L.	51	1 × 1	3	Varicose	Healed	A controlled diabetic
C. W.	81	1 × 1½	6	Ischemic	Healed	Moderate arteriosclerosis of leg
H. T.	79	1 × 1	6	Ischemic	Healed	Moderate arteriosclerosis of leg
L. S.	58	1 × 4	8	Varicose	Healed	15 weeks with Unna boot; no improvement
M. A.	38	2 × 2	8	Varicose	Healed	
K. M.	42	2 × 3	9	Varicose	Healed	125 weeks' treatment with Unna boots and various locally applied drugs with only slight improvement
A. T.	66	2 × 3	11	Ischemic and varicose	Healed	Chlorophyl-penicillin ointment used locally; first healing in 10 years
M. L.	55	3 × 4½	14	Varicose	Improved	Deep phlebothrombosis; femoral ligation and skin graft done before complete healing
M. H.	62	2½ × 3	10	Varicose	Healed	Recurrence in one month; required skin graft
C. S.	52	6 × 9 5 × 5 5 × 8	11	Varicose	Improved	Required femoral vein ligation and skin graft to effect healing because of deep phlebothrombosis
H. C.	29	2 × 2½	11	Trophic	Improved	Skin graft necessary to effect healing
J. M.	71	1½ × 6 2 × 4	20	Ischemic	Improved	Last 8 weeks of treatment, chlorophyl-penicillin ointment used with excellent response; skin graft done to effect complete healing
S. N.	63	3 × 3	12	Ischemic	Healed	
R. K.	54	5 × 8 2 × 3	12 4	Ischemic	Improved	Cardiac-obesity, 330 pounds
L. O.	34	2 × 3	3	Varicose	Healed	
S. B.	68	3 × 3	6	Ischemic	Healed	

fascia. If there are any varicosities feeding the ulcer, they are ligated as encountered. The scar tissue and ulcer are then excised and the wound is allowed to form healthy granulations which are skin grafted. We have tried less extensive operations such as excising the scar tissue on each side of the ulcer and sliding a full-thickness pedicle graft over the ulcer. In our hands this procedure has not been as successful as complete removal of the entire ulcer and scar tissue.

This extensive plastic operation is necessary only in those few cases where long-standing or repeated ulceration has built up a thick cicatricial periphery. In most instances we have found that failure to heal completely has been due to the presence of poor epithelial tissue. This is particularly true where the ulcer measures 3 cm. or more in diameter. These larger ulcers tend to form a very thin, avascular type of epithelium. Skin grafting such ulcers, once healthy granulation tissue has formed, not only lessens the period of disability by weeks but also affords the best insurance against recurrence.

In Table III is illustrated the value of skin grafting in long-standing or recurrent ulcers. While one lesson to be learned from these cases is that skin

TABLE III. SKIN GRAFTED CASES

CASE	AGE (IN YR.)	DURATION OF ULCER (IN YR.)	SIZE OF ULCER (IN CM.)	WEEKS OF TREATMENT	TREATMENT	RESULT
M. L.	55	15	2½ × 2½	3	Femoral vein ligation followed by pinch graft	Healed
C. S.	52	12	5 × 7	5	Femoral vein ligation followed by pinch graft; saphenous ligations previously done and skin graft failed	Healed
H. C.	29	2	2 × 2	4	A trophic ulcer with good arterial and venous circulation; all other forms of treatment failed; skin graft was done in out-patient department and patient remained ambulatory	Healed
J. M.	71	8/12	1½ × 1½ and 1½ × 2	2	Ulcer, originally 12 × 18 cm., reduced in size by pressure dressings; finally reached a static stage when pinch grafts were applied	Healed
M. H.	62	5	2½ × 3	3	Recurrent ulcer which failed to respond to local treatment until skin graft was done	Healed
E. A.	62	34	2½ × 2½	8	Plastic excision of ulcer first done because of scar tissue with skin graft delayed until new granulation formed; preliminary high saphenous vein ligation	Healed

grafting will effect a cure when all else fails, a much more important deduction is that the patient can be saved months and years of suffering and disability when large or recurrent ulcers receive early skin grafting.

Pinch Grafts.—Preliminary to skin grafting of ulcers we believe that all varicosities should be adequately treated by ligation and sclerosis, the ulcer bed must be free of infection, the skin circulation must be adequate as determined by fluorescein dye tests, and avitaminosis, hypoproteinemia, and anemia, if present, must be corrected.

The most successful skin graft method judged by the percentage of takes, time of donor and recipient areas to heal, and comfort to the patient is the pinch or Reverdin type. Two per cent novocain infiltration anesthesia is used. The anterior or lateral thigh is selected as the donor site. Small thin pinch grafts are removed from a prepared area, dipped into plasma, and then planted, cut surface down into the clean granulation tissue of the ulcer over which thrombin topical solution has been applied. This coagulates the plasma and sticks the grafts more securely in place. The donor and recipient areas are then covered by coarse mesh paraffin gauze, petrolatum gauze, fluffed plain gauze, a cotton pad, and bandaged with a cotton elastic bandage as a pressure dressing. Both areas are dressed on the seventh or eight day. The "takes" have been well above 90 per cent in all cases and remained successful in all but one. In this case the grafts remained until the patient was ambulatory for two weeks. Then they gradually sloughed away because of poor circulation shown by tests. The grafts were repeated two weeks after a femoral vein ligation and they are successful after four months of ambulation.

When dealing with leg ulcers in patients who give a history of an old deep phlebothrombosis, it is often impossible to improve the circulation by the usual methods. As a result ulcers in such cases are hard to heal. We have found that ligation of the femoral vein below the profunda as originally advocated by Homans[9] and later by Coller and Buxton[10] improves the circulation considerably and permits the successful skin grafting of the ulcer site. We do not follow Homans' advice regarding not ligating the saphenous vein. We ligate both the saphenous and the femoral veins and have found it very helpful to the patient. Except for some temporary cramping and a slight degree of swelling lasting for several months, we have noted no untoward aftereffects.

SUMMARY

1. A careful history and physical examination with special attention to signs and symptoms of other peripheral vascular diseases is necessary to determine the cause of leg ulcers.

2. Fluorescein dye tests have proved helpful to determine the condition of the circulation around the ulcer site. This test is more easily performed than skin temperature and oscillometric determinations and yields almost as much information.

3. Local treatment is a necessary adjunct to surgical management. In our experience the most useful local treatment has been gentian violet solution, sulfathiazole crystals, and compression bandages of sponge rubber.

4. Surgical correction of ulcer causative factors should follow as closely as possible the local treatment of the ulcer. Surgical measures include vein ligations, plastic operations on old ulcers, and skin grafting of larger ulcers, as indicated in each case.

5. The authors' technique for skin grafting is described.

6. The results of pressure dressings with Unna's paste boot and sponge rubber in thirty-four cases is presented in tabulated form.

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A SIMPLE DEVICE TO TEST AND TO IMPROVE THE CIRCULATION IN A PEDICLE FLAP

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IN CONSTRUCTING and transplanting a pedicle flap, aside from certain general rules, such as selecting the proper donor area, outlining the flap, allowing for shrinkage, and cutting the flap of equal thickness, a sufficient arterial and venous circulation in the flap is of utmost importance. A flap, with a broad pedicle and not longer than twice the width of the pedicle and the flap lying along the axis of the circulation of the donor area, can as a rule be immediately transferred. In long narrow flaps, however, and those crossing the long axis of the circulation of the donor area, transfer should be delayed for the purpose of securing an adequate blood supply. There are, however, cases in between these two extremes, where the question as to immediate or delayed transfer can be answered only by testing the circulation of the flap. An accurate test of the blood supply of a flap is also helpful whenever a flap must be severed from its pedicle or whenever a double pedicle flap is to be converted into a single pedicle flap. There are various ways of testing the circulation as, for instance, the temperature return test of Douglas and Buchholz, and the fluorescin test of Dingwall and Lord. I found the method to be described here simple and versatile. As a matter of fact, it is so simple that it may have been used by others. However, as far as can be ascertained, it has not been described in literature as yet.

The test is made by means of an ordinary laboratory clamp. The clamp, however, should be of the type depicted in Fig. 1, that is, it should be closed on all four sides. The lower crossbar, however, should be rotatory so that it can be swung open like a door. The clamp is attached to that pedicle of a flap which needs to be severed. The clamp is applied as follows: The crushing bar of the clamp is raised by turning on the thumb screw. The lower bar is open. The pedicle of the flap is inserted into the space below the crushing bar. The lower bar is swung back in place, thus closing the space in which the pedicle lies. The pedicle is now gradually clamped by setting up on the thumb screw until the color of the flap changes. It is then possible to determine the adequacy of the circulation: The tip of the finger is pressed upon the flap near the clamp for a few seconds; this leaves an anemic mark which, if the circulation is adequate, returns to normal immediately. If the return to normal color is slow, or absent, the pressure of the clamp is lessened by turning the thumb screw in the reverse way. If the crushing causes pain, a few cubic centimeters of novocain should be injected into the pedicle.

The great advantage of this test is its accuracy and simplicity of application. Also, the clamp is not bulky. A few examples will demonstrate the versatility of the method.

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The laboratory clamp test may be applied to an open pedicle flap. The open pedicle flap as distinguished from the tube flap can be used whenever a direct approach of flap and host area can be accomplished, no matter whether the flap is transferred to the host area or the host area to the flap. Whenever the length or location of a flap is such as to cast doubt concerning the adequacy of its circulation, the flap is raised between two parallel incisions and left attached temporarily at two pedicles (bridge flap). The pedicle, which is to become the peripheral end of the flap, is clamped with an elastic intestinal clamp. If the color of the flap does not change, this pedicle of the flap can be severed and the flap transferred immediately. If the color changes, transfer should be

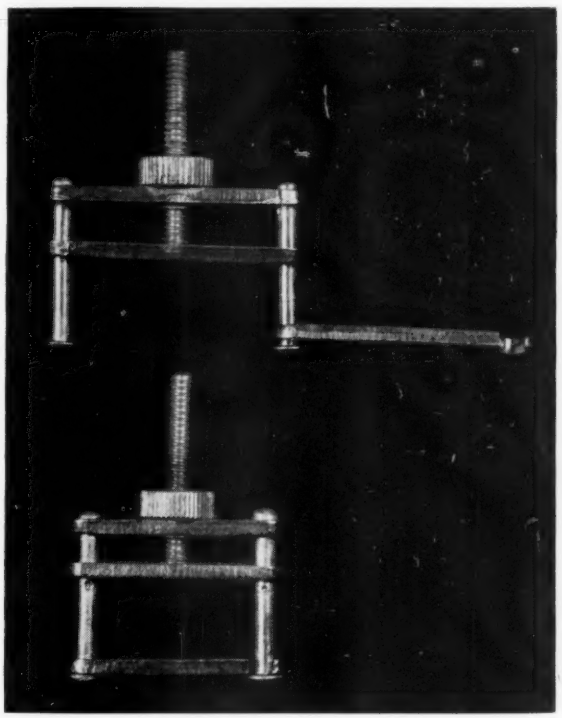


Fig. 1.—A medium-sized and small laboratory clamp. The lower crossbar is rotatory so that it can be swung open like a door.

delayed and the circulation improved by application of the laboratory clamp to the peripheral pedicle of the flap. The latter is narrowed by incising it from either side for one-third of its distance, leaving the middle third preserved. The laboratory clamp is now attached to the middle third and all wound edges are sutured together. The following day gradual crushing of the narrowed pedicle is begun by tightening the clamp. After each tightening the adequacy of the circulation is tested as just described. After the pedicle is crushed completely, the clamp can be removed and the flap may be ready for transfer, unless the crushing has caused edema in the flap. If this is the case, transfer should be delayed until all edema has subsided. Immediate application of the laboratory clamp may be inadvisable in flaps which show marked change of color

A.

B.

C.

D.

Fig. 2.—*A*, Patient, aged 52 years, referred to us for treatment of a deep decubital ulcer of right heel from pressure of plaster cast. The original injury was a compound fracture of the right leg. *B*, A flap was raised from the lateral surface of the left leg between two parallel incisions. Clamping of the peripheral pedicle with an intestinal clamp caused marked cyanosis of the flap. Hence, the flap was returned to its original site. After six weeks the flap was raised again, its peripheral pedicle narrowed one-third from either side. A laboratory clamp was applied to the middle third and the flap returned to its original site. Remainder of the pedicle was gradually crushed within five days and the clamp removed. Two weeks later all edema had disappeared from the flap. The flap was raised again. The peripheral end, however, became discolored, hence, flap was returned once more. *C*, One week later the flap was raised. The area from which the flap was raised was skin grafted. The ulcerated area at the right heel was excised, the right leg crossed, and the flap sutured into the defect. Both legs were immobilized in a plaster cast. *D*, Seven days later the laboratory clamp was applied to the pedicle of the flap, and the pedicle was gradually crushed within three days. The pedicle was then severed and the cast removed. One week later the free end of the pedicle at the left leg, as well as the free end of the flap at the right heel, were adjusted in place. Weight-bearing was not permitted for four weeks.

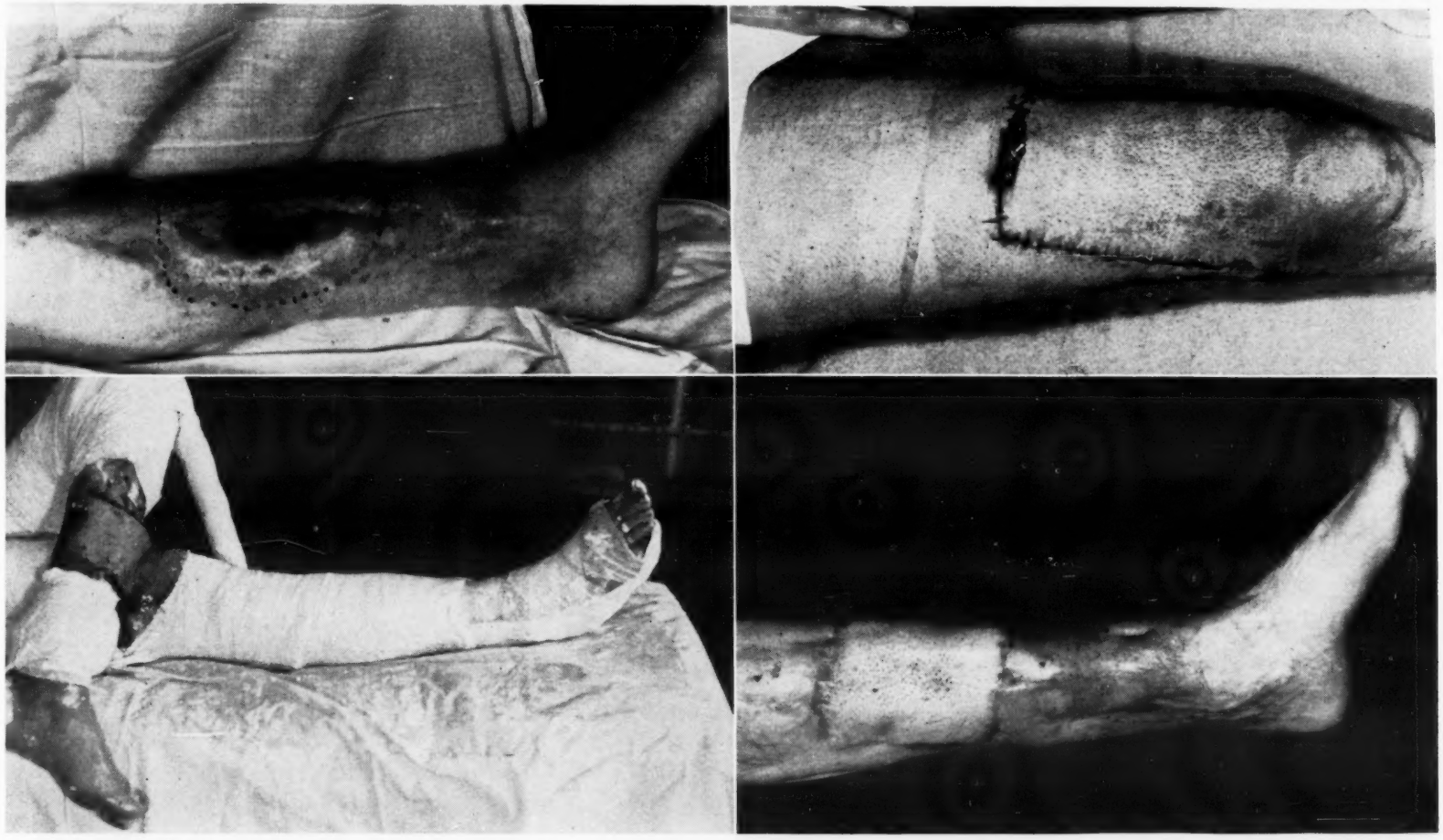
A.

B.

the right heel was excised, the right leg crossed, and the flap sutured into the defect. Both legs were immobilized in a plaster cast. *D*, Seven days later the laboratory clamp was applied to the pedicle of the flap, and the pedicle was gradually crushed within three days. The pedicle was then severed and the cast removed. One week later the free end of the pedicle at the left leg, as well as the free end of the flap at the right heel, were adjusted in place. Weight-bearing was not permitted for four weeks.

A.

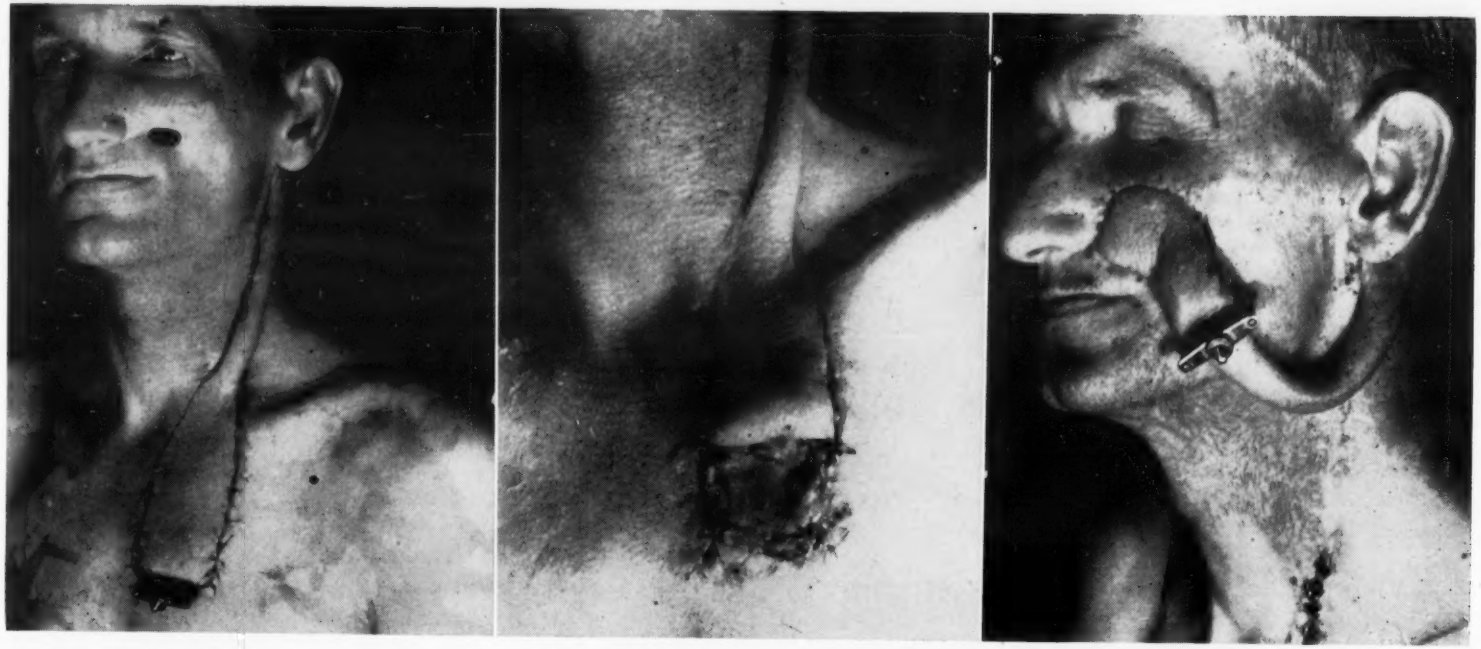
B.



C.

D.

Fig. 3.—*A*, Patient with extensive scarring ulceration and sequestration over left tibia from osteomyelitis. *B*, A large double pedicle flap was raised at the right thigh. First the upper half was mobilized between two parallel incisions and returned to its original site. Two weeks later the entire flap was mobilized and returned to its original site. Two weeks after this the flap was elevated again, the peripheral pedicle was narrowed one-third from either side, and the laboratory clamp was applied to the middle bridge. The pedicle was crushed gradually within one week. Three weeks later after all edema had subsided, the entire flap was raised. The peripheral end became discolored, hence, the flap was again returned to its original site. *C*, Two weeks later the flap was again raised. The scars over the tibia were removed. The tibia was saucerized. All sequestra were removed. The leg was crossed and the flap sutured in place after the flap bed had been skin grafted. Ten days later the pedicle of the flap was narrowed from either side and the laboratory clamp applied to the middle section. The remainder of the pedicle was gradually clamped within one week. The cast was removed. Three weeks later the flap was adjusted in place. *D*, Patient three months after operation.



A. *B.* *C.*

Fig. 4 *A-C.*—*A*, Patient, aged 46 years, referred for closure of a full thickness defect of the left cheek after irradiation of cancer. Frequent biopsies were negative. A cervical tube flap was constructed reaching from the left mastoid region to the clavicle. Three weeks later the flap was lengthened. This part of the flap was left untubed and returned to its original site. Two weeks later it was elevated again, the peripheral pedicle narrowed from either side and the laboratory clamp attached to the remainder of the pedicle. The pedicle was gradually crushed within five days. *B*, Four weeks later the peripheral edge of the untubed flap was raised and lined by folding it upon itself. The flap bed was skin grafted. *C*, Three weeks later the communication of covering and lining of the flap, that is the peripheral edge of the flap, was incised. One week later the flap was sutured into the defect. Ten days later the pedicle was gradually crushed with a laboratory clamp. This took four days, when the flap could be severed from the pedicle and adjusted in place.

upon application of the intestinal clamp. If this is the case, the flap should be returned to its original site and sutured in place. After three weeks the flap is raised again and the laboratory clamp is applied as described. After the pedicle is crushed one should wait until all edema has subsided before transferring the flap. As a matter of fact, in some instances where the circulation was particularly poor, another raising and returning of the flap—the flap now being a single pedicle flap—may be advisable (Figs. 2 to 4).

D. *E.*

Fig. 4 *D* and *E*.—Patient one year after operation.

After the transfer of the flap, the laboratory clamp method is again useful in separating the flap from its pedicle. It is also applicable to tube flaps. The skin at the site of the crushing of the tube flap, however, should be incised all around the tube, rendering the area more pliable and less painful.

SUMMARY

With the aid of an ordinary laboratory clamp, which is closed on all four sides but has a rotatory lower crossbar, it is possible to test and to improve the circulation in a pedicle flap. Several examples are depicted, which demonstrate the method.

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THE TREATMENT OF SUPERFICIAL PYOGENIC INFECTIONS BY THE DIRECT INJECTION OF PENICILLIN

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FOR the past eighteen months I have been treating superficial pyogenic infections by the daily injection of a penicillin-novocain mixture directly into the involved tissues. It has been observed that after one or two such treatments pain and redness usually disappear, and that after five or six injections all evidence of infection is usually absent and the healing process well established. In fact, the response of the infections thus treated has been so rapid and satisfactory that it suggests that this method of treatment may be superior to the orthodox methods such as heat, rest, elevation of the affected part, or the systemic administration of sulfonamide derivatives or penicillin. At my suggestion several other medical officers have also followed this procedure and have been equally successful. Because of lack of facilities it has not been possible to review exhaustively the literature on penicillin, but it is my impression that the technique to be described has not been previously published.*

The solution used was made by dissolving 100,000 units of penicillin in 100-c.c. of normal saline and adding 100 c.c. of 1 per cent novocain, the final strength being 500 units per cubic centimeter in 0.5 per cent novocain. This strength of penicillin was selected because it had previously been found to be nonirritating to the eye† and should therefore be nonirritating to other tissues. The novocain was added to minimize the pain associated with the injection of penicillin into an inflamed area. The patients were all Army personnel with some type of an acute infectious process involving the skin and subcutaneous tissues.

If pus was present the skin was infiltrated with the mixture, incised, and gross slough removed. The area of obvious inflammation and a 1 to 4 cm. band of surrounding normal tissue were then heavily infiltrated with the solution, from 15 to 150 c.c. of solution being used depending on the size of the lesion. This was done by beginning at the periphery and working toward the lesion. As a final step the center of the lesion was infiltrated through the abscess wall, if present, to insure a high concentration at the point of maximum injection. By starting at the periphery, the possibility of forcing organisms out into uninvolved tissues is avoided. It is to be emphasized that several of the rules for handling infected tissues were grossly violated in that (1) injection of the solution was made directly into infected tissues by passing the needle through the walls of abscess cavities or through inflamed skin,

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*After this manuscript had been completed, an article was found which described a similar technique. Rose, D., and Hurwitz, D.: The Regional Injection of Penicillin in Local Infections, New England J. Med. 234: 291, 1946.

†Morris, Frank O'N.: Personal communication.

(2) infected tissues were grossly distended with the solution to insure a heavy concentration of penicillin in and around the area of infection, and (3) frequently no attempt was made to put the involved area at rest. Injections were repeated each twenty-four hours until all evidence of infection had disappeared, a matter of three to seven days. Supplementary therapy was omitted except in a few cases in which heat, rest, and elevation of the affected part were used. The use of sulfonamide derivatives or penicillin systemically was avoided.

Bacteriologic studies were attempted on a number of the patients treated. However, due to the inexperience of the laboratory personnel, isolation of various strains of organisms was unsatisfactory. Frequently the reports, such as Sarcinia, suggested contamination of the cultures. Therefore, it is not possible to report on this aspect. Clinically the causative organism in all cases, except the patients with Vincent's infection, appeared to be some strain of streptococcus or staphylococcus.

A brief description of the various types of lesions treated and the results obtained follows:

1. *Carbuncles.*—There were four cases of carbuncles, two on the dorsum of the hand, one on the neck, and one on the back, varying in size from 5 to 12 cm. in diameter. These were in the suppurative stage when first seen and at the time of the initial injection cruciate incisions were made and slough removed, but no tissue was excised. From 100 to 150 c.c. of penicillin solution were injected daily for five to seven days. At the end of this time there was no evidence of infection and healing had begun. There was no supplementary therapy; two patients were treated on an ambulatory basis. The striking feature in each case was the very rapid subsidence of pain, swelling, and redness, within twenty-four to forty-eight hours, and the early appearance of the healing process. It was estimated that complete healing occurred in about two-thirds the time ordinarily to be expected with orthodox methods of treatment.

2. *Vincent's Infection of the Tonsils.*—There were three cases of Vincent's infection of the tonsils. Each patient had been proved resistant to all the usual forms of treatment, including large amount of systemic penicillin, and had had either several rapid recurrences or else a long period of hospitalization without improvement. The peritonsillar tissues were injected with 20 to 30 c.c. of solution each day for from five to seven days with complete subsidence of all infection. There were no recurrences during a three-month follow-up period. The results obtained in these cases are considered highly significant because each patient had a chronic infection which for a long period of time had been resistant to the common methods of treatment.

3. *Miscellaneous Skin Infections.*—There were seventy-two miscellaneous skin infections, including boils, furuncles, cellulitis, etc. These were the common run of skin infections—boils with and without cellulitis, furuncles of the arm or leg, infected sebaceous cysts, cellulitis of the dorsum of the foot and ankle secondary to trichophytosis, cellulitis of the hand or arm secondary to cuts or scratches, and so on. Some of these infections were on the face and several involved the nose, supralabial or infraorbital area.

Depending on the size and severity of the infection, the patients in this group received from two to seven injections of penicillin of 15 to 50 c.c. each time. Usually there was prompt relief from pain, within twenty-four hours, and rapid subsidence of evidence of infection within forty-eight to seventy-two hours. Most of these patients were treated on an ambulatory basis and it is believed that many hospital days were saved by this therapy. It is also believed that those patients who were hospitalized were returned to full duty much more rapidly than they would have been had they been treated by the more conventional methods of heat, elevation, and rest to the affected part, or by systemic sulfonamide or penicillin.

4. *Hand Infections.*—Several felons and paronychia were treated by this method, in each instance after establishing adequate drainage. Rapid subsidence of infection was noted.

5. *Pilonidal Cysts.*—There were twenty cases of pilonidal cysts. The preparation was used in two different ways in these cases: *Acute abscesses* were treated as described under Miscellaneous Skin Infections. However, if it was decided to excise the cyst the injections were continued for a total of ten days, at which time the area was usually suitable for excision and primary closure, provided the method to be described later was followed. *At operation,* after excision of the cyst and its sinus tracts and after mobilization of sufficient surrounding tissue to permit primary closure without tension, all the tissues in the area of excision and mobilization, especially the fat, were heavily infiltrated, using from 200 to 300 c.c. of penicillin. The solution contained no novocain in this instance. Twelve cases were handled in this manner with primary union and no drainage of any kind, in each instance.

6. *Deep Infections.*—One patient had a *chronic infection of the submaxillary salivary gland.* This patient had had repeated episodes of an acute inflammatory nature which had required drainage. When first seen he was in an acute exacerbation of the infection. Drainage was established and the infected tissues were infiltrated daily with penicillin. Ten days later the gland was excised, the wound infiltrated with penicillin, and closed without drainage. There was primary union. One patient with *acute axillary abscess* had a past history of a similar infection which had been quite stubborn and had required repeated incision and drainage. Drainage was established and the axilla infiltrated daily with about 75 c.c. of solution. There was early subsidence of infection and no recurrence. One patient had a *chronic draining axillary sinus* tract following drainage of a deep axillary abscess. A ten-day period of daily injections of the axilla with penicillin failed to stop drainage. The tract was dissected out and found to terminate in a partially destroyed lymph node. The operative wound was thoroughly infiltrated with penicillin and the wound closed without drainage. Healing was by primary intention.

7. *Contaminated Wounds or Operative Fields.*—The preparation has been used as a local anesthetic in the treatment of a number of contaminated wounds such as are seen in accident cases, after fights and the like. The tissues involved were heavily infiltrated, carefully cleansed, and thoroughly débrided in the usual manner and closed primarily without drainage. There

were no infections. The same procedure was carried out in operative fields which were sites of known infections as has been previously described under Pilonidal Cysts and Deep Infections. Primary union without drainage was obtained in each instance.

DISCUSSION

It is a well-known fact that penicillin is normally only a very temporary guest of the human body, reaching its peak concentration about one hour after intramuscular injection, and being largely excreted within three hours. It is likewise known that while some bacteria are susceptible to this drug at the usual low concentration achieved in body tissues others succumb only at higher levels than are attainable by systemic penicillin.

Because of these factors—low concentration, rapid excretion, and variable bacterial susceptibility—frequent injections of large amounts of systemic penicillin for periods of four to ten days are usually required to control localized pyogenic infections such as those described in this paper. Furthermore, some pyogenic infections respond poorly or not at all to systemic penicillin. It was believed that if a method could be found whereby a very high local concentration of penicillin could be obtained, there might be more rapid subsidence of the infection, injections could be made at longer intervals, and some infections not amenable to systemic penicillin might be controlled. The direct injection of penicillin into the infected area was the only method which seemed to offer the possibility of obtaining the high local concentration desired. When this was done, injecting penicillin directly into the infected area, the results obtained indicated that the infection was usually controlled more rapidly, healing began earlier and it was completed faster than when comparable cases were treated with systemic penicillin. The most significant results were obtained in the three patients with Vincent's infection of the tonsil because this method succeeded where systemic penicillin had failed. These observations lead to the belief that many localized infections which respond slowly or not at all to systemic therapy can be treated successfully and more rapidly by the local injection of penicillin.

The solution used was weak, 500 units per cubic centimeter, and was deliberately chosen to minimize the tissue irritant effect of the drug. There is no logical reason why higher concentrations should not be used, except that this may lead to more residual soreness after the effect of the novocain has disappeared. This has been noted in a few cases in which solutions of 2,000 units per cubic centimeter have been used. However, in severe and spreading infections higher concentrations, up to 50,000 to 60,000 units per cubic centimeter, would certainly seem best. The twenty-four hour interval between injections, while satisfactory in the patients treated, is entirely arbitrary and in more severe, or in spreading infections, injections at twelve-, eight-, or even four-hour intervals are probably desirable.

It is to be emphasized that the usual rules of providing drainage for accumulations of pus must be followed. However, it is believed that the surgery can be more limited, as in carbuncles where excision of tissue was not found to be necessary.

Of particular interest are the results obtained by using it to infiltrate the contaminated wound seen in accident cases, or the definitely "dirty" operative field such as is found after the excision of pilonidal cysts. When the tissues of such wounds were heavily infiltrated, they were closed without drainage and no infection developed. This opens a wide field of use and may well make possible the carrying out of extensive procedures in infected or contaminated fields, which heretofore were dangerous because of the high incidence of postoperative wound infection. The closure of colostomies and fecal fistulas are examples of such cases.

This method of therapy also eliminates the need of frequent injections of penicillin and thus makes possible the ambulatory treatment of many patients who would otherwise have to be hospitalized. It is also my impression that the infections so treated have cleared up more rapidly than have similar ones treated by heat, rest, elevation, and the systemic administration of sulfonamide derivatives or penicillin. They have therefore resumed normal activities at an earlier date. Both of these factors are of considerable economic importance to the average patient.

SUMMARY

Approximately 100 patients with pyogenic infections of the skin and subcutaneous tissue have been treated by the direct injection into the involved tissues of a mixture of penicillin and novocain. In all cases the infection subsided rapidly, and in most cases it appeared to subside more rapidly than did comparable cases treated by heat, rest, elevation, or the systemic administration of sulfonamide derivatives or penicillin. There were no failures and no complications. Three cases of Vincent's infection of the tonsil which had been resistant to all forms of treatment including systemic penicillin were cured by the local injection of penicillin.

In fourteen operations in contaminated fields, as in excising a pilonidal cyst, the wound was infiltrated with penicillin and closed without drainage. There were no postoperative infections.

CONCLUSIONS

1. The direct injection of penicillin in superficial pyogenic infections is a safe and practical method of treatment.

2. Infections so treated responded as rapidly as, or more rapidly than, similar infections treated in the orthodox manner with heat, rest, elevation, or the systemic administration of sulfonamide derivatives or penicillin.

3. Some infections which cannot be successfully treated by, or which respond very slowly to, systemic penicillin can be treated rapidly and successfully by injecting penicillin directly into the infected tissues.

4. Contaminated operative wounds can be closed without drainage and without fear of postoperative infection, if the tissues are heavily infiltrated with penicillin.

The author wishes to express his gratitude to Major Frank O'N. Morris, and Captain F. W. James, Medical Corps, Army of the United States, for their assistance.

EFFECTS OF PROTEIN AND METHIONINE ON NITROGEN BALANCE OF BURNED RATS

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IT IS well established[1] that the urinary nitrogen excretion is markedly increased after thermal injury. Evidence presented by Croft and Peters[2] (1945) indicates that the loss in urinary nitrogen of burned rats is substantially reduced by the incorporation of 1 per cent methionine in the diet. The suggestion is made that the negative nitrogen balance or "the apparent toxemia is in reality a deficiency, induced by a call for one amino acid with consequent raiding of a whole protein molecule." It was felt that the importance of such a hypothesis warrants further investigation of this problem.

METHODS

Male rats, 70 days of age, were used. The experimental diets are listed in Table I.

One gram of the following mixture was added to each 99 Gm. of diet:

Thiamine	20 mg.
Vitamin K	4 mg.
Pyridoxine	20 mg.
Para amino benzoic acid	50 mg.
Nicotinic acid	100 mg.
Calcium pantothenate	280 mg.
Choline chloride	5,000 mg.

These materials were dissolved in 100 c.c. of 20 per cent ethanol, and a 1 c.c. aliquot was added to each 100 Gm. of diet. Proper amounts of vitamins A, D, and E were fed as supplements twice weekly.

The animals were fed the respective diets for at least one week in stock cages before being placed in the metabolism cage. The food cups in the metabolism cages, which were equipped with removable metal collars, were placed within glass containers to prevent the scattering of food. The food intake was measured daily to the nearest gram. Tap water was always available in a water fountain. The animals rested on the screened bottoms of the cages. The metal funnel under the cage was coated with paraffin and the urine was collected daily in a graduate containing 5 c.c. of dilute H_2SO_4. The funnel was washed with water each day and the washings collected. The urine volume was measured and brought to 200 c.c. with the washings and distilled water, and aliquots were analyzed for nitrogen by the Kjeldahl procedure.

This work was done under contract with the Medical Division of the Chemical Warfare Service.
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TABLE I

DIET	I	II	III
Casein	20	20	40
Salt mixture[3]	4	4	4
Crisco	8	8	8
Sucrose	65	64	45
Agar	2	2	2
Vitamin supplement*	1	1	1
Methionine	–	1	–
Nitrogen analysis	2.92%	2.98%	5.92%

*Vitamin supplement: Sucrose, 195.9 Gm.; inositol, 4.0 Gm.; riboflavin, 0.1 Gm.

Fecal contamination of the urine was prevented by using a fine screen at the bottom of the funnel.

After anesthetizing the rats lightly with sodium pentobarbital, about one-third of the body surface was burned by dipping the clipped back in water at 75° C. for sixty seconds. A hard crust formed over the burned area after a few days and no "weeping" was encountered. An occasional animal died within a few hours after burning.

The first set of experiments (A) involved the feeding of the basal diet containing 20 per cent casein to twelve rats (I), the basal diet + 1 per cent methionine to twelve rats (II), and a diet containing 40 per cent casein to eight rats (III). This work was done during the summer months when the temperature in the laboratory was comparatively high. It was repeated (B) during the late fall months with Diets I and II (five rats for each diet) when the laboratory temperatures averaged about 22° C.

The standard error of the mean was determined by the formula

$$\sigma = \sqrt{\frac{d^2}{n\ (n-1)}}$$

in which d is the deviation from the mean and n is the number of animals. The statistical differences between means were calculated according to standard procedures.

RESULTS

The figure for nitrogen intake minus the urinary nitrogen was considered to represent the nitrogen balance. The fecal nitrogen determined for the control and burn periods was fairly constant and was not considered. It was found impossible to obtain a constant daily food intake and nitrogen output for the control period when the animals were allowed to ingest the food ad libitum. The nitrogen output varied daily for a given animal. Control periods were run from four to nine days in the A groups, and for seventeen days in the B groups.

The means and the standard errors of the means are used for the presentation of the data in each group. The data for both sets of experiments are shown in Table II.

The rats in group A weighed between 150 and 210 grams at the time they were placed in the metabolism cages. Their weights increased during the control period. After burning, most of the rats showed a slight decrease in

TABLE II. AVERAGE VALUES WITH STANDARD ERRORS OF NITROGEN BALANCE IN RATS*

DIET	GROUP A 1	2	3	4	5	6	7
			Control Period				
I (12)†	216 ± 14	173 ± 12	186 ± 16	156 ± 12	–	–	–
II (12)	166 ± 9	141 ± 11	142 ± 15	148 ± 11	–	–	–
III (8)	125 ± 38	175 ± 25	161 ± 26	258 ± 24	–	–	–
			Burn Period (Days After Burning)				
I	−115 ± 13	−29 ± 31	−48 ± 25	4 ± 22	91 ± 19	126 ± 15	93 ± 19
II	−132 ± 18	−52 ± 32	−70 ± 33	88 ± 34	52 ± 40	110 ± 35	73 ± 24
III	−156 ± 34	−35 ± 26	53 ± 32	178 ± 75	22 ± 70	103 ± 31	143 ± 42

DIET	GROUP B 8	7	6	5	4	3	2	1
				Control Period (Days Before Burning)				
I (5)	90 ± 14	131 ± 21	103 ± 5	99 ± 14	74 ± 22	123 ± 15	101 ± 11	112 ± 14
II (5)	105 ± 14	111 ± 20	75 ± 16	121 ± 16	107 ± 19	131 ± 12	103 ± 32	170 ± 18
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
				Burn Period (Days After Burning)				
I	− 86 ± 26	−115 ± 35	−44 ± 48	66 ± 10	0 ± 43	116 ± 20	47 ± 36	65 ± 16
II	−116 ± 21	− 51 ± 59	19 ± 28	15 ± 26	89 ± 18	164 ± 41	1 ± 51	158 ± 38

*Nitrogen intake, nitrogen urinary excretion in milligrams.
†Figures in parentheses represent number of animals.

weight which persisted during the period of observation. The animals in group B lost little weight during the burn period and in some cases tended to increase in weight.

In all cases the voluntary food intake markedly decreased from the control levels during the first two days after burning. In some animals the food intake remained below normal during the entire experimental period.

In group A (Table II) the mean values for "nitrogen balance" during the first four days of the control period were chosen as standards for comparison with the postburn period. The values on the first day for Diet I and the fourth day for Diet III are too high to conform with other control data. No statistically significant differences were noted in nitrogen retention during the control period except for the two values mentioned. It will be seen that there is a marked negative nitrogen balance immediately after thermal injury, which is apparently due to a combination of excessive nitrogen excretion associated with tissue destruction and to loss of appetite. Within a few days, the animals begin to ingest more food and retain nitrogen. A comparison of the mean values during the postburn period shows that there are no statistical differences between the basal, the methionine-basal enriched, and the high protein diets on any given day.

In group B, which was studied during cooler weather, the nitrogen retention was less than that observed for group A, which may be due to the difference in temperature. A comparison of the mean values for group B (Table II) during the control and burn periods shows no statistical differences between the data for nitrogen balance of rats on a basal and a methionine-enriched basal diet.

DISCUSSION

Although the experimental procedures used in these experiments differ somewhat from those described by Croft and Peters, we were unable to con-

firm their findings. The English investigators fed definite amounts of a basal diet containing 10 per cent casein and 10 per cent dried yeast daily. The animals were withdrawn from the metabolism cages for three hours each day for feeding in order to avoid contamination of the urine samples. The urea and ammonia nitrogen alone were determined as a measure of nitrogen metabolism. In the present experiments, the rats were fed ad libitum, a twenty-four hour specimen of urine was collected, and total nitrogen was determined. Furthermore, these rats were burned at 75° C. for sixty seconds in comparison with the exposure at 73° C. for thirty seconds by Croft and Peters.

Several investigators have failed to confirm the findings of Croft and Peters.[2] Browne, Schenker, and Andreae[4] (1945) studied the nitrogen metabolism in patients suffering from thermal burns whose diets were supplemented with methionine. They found that the excretion of urinary nitrogen is not sufficiently affected after feeding this amino acid to warrant its use in burned patients. Abbott, Meyer, and Hirshfeld[5] studied the nitrogen excretion of burned dogs and were unable to note any significant difference in those animals receiving methionine over the control dogs.

SUMMARY

The intake and excretion of nitrogen in white rats fed on a 20 per cent casein basal diet, a basal diet supplemented with methionine, and a diet containing 40 per cent casein were determined before and after burning with hot water. During the first few days after thermal injury, all animals were in negative nitrogen balance. Neither the addition of methionine nor increased protein ingestion affected the retention of nitrogen significantly.

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Case Reports

PENETRATING HEART WOUND

The Report of an Interesting Case

Major Robert W. Robertson, Medical Corps, Army of the United States

A PATIENT was wounded in the chest at 8:45 P.M. March 22, 1945, when an enemy machine-gun bullet ricocheted off a stone wall. He was admitted to the 33rd Field Hospital, "B" Unit, at 11:15 with a sucking wound in the first interspace on the right side just lateral to the sternum. At that time the patient was cyanotic and respiration was difficult and painful. The sucking wound had been sealed airtight with a petrolatum gauze dressing. There was no other wound visible externally. The blood pressure on admittance was 120/20, the pulse 108 per minute, and the respirations were 30 per minute.

The preoperative radiographic picture of the chest showed a right hemopneumothorax with a mediastinal shift to the left (Fig. 1). A small foreign body the size of a split pea was present in the first interspace just to the right of the sternum. The radiographic picture of the pelvis on lateral view showed a bullet at the level of and just anterior to the lower border of the fifth lumbar vertebrae. The anteroposterior view showed the bullet lying obliquely on the left side just medial to the sacroiliac joint (Figs. 2 and 3).

The patient was prepared for surgery by aspiration of 500 c.c. of blood from the right pleural cavity, the administration of 500 c.c. of blood intravenously, nasal oxygen, and 50,000 units of penicillin intramuscularly.

Operation.—An incision was made extending laterally and medially from the wound of entrance in the first interspace (anesthesia, gas [N_2O] oxygen ether endotracheal). The anterior surface of the upper lobe of the right lung was seen to have a two-inch laceration. As the lacerated area was being drawn laterally into the operative field a severe hemorrhage started from the mediastinal area. The whole pleural cavity seemed to fill with blood which was supposed to be originating from the pulmonary vessels or heart. The blood pressure immediately fell to zero. A formal thoracotomy was rapidly done by resecting a five-inch segment of the third costal cartilage and rib. Blood was seen to be flowing from an opening, one-half inch in diameter, in the upper lateral wall of the pericardium. This opening was enlarged and a one-half to three-quarter inch laceration was visible at the junction of the superior vena cava and right auricle anteriorly. For more adequate exposure the thoracotomy was extended medially resecting completely a section of the sternum over this area. The laceration was now seen to be about one-half in the superior vena cava and one-half in the auricle. This wound was closed with a double layer of fine silk sutures. The pericardium was closed tightly after further exploration showed no other myocardial or pericardial damage.

The laceration of the upper lobe of the right lung was closed using a double row of intestinal catgut. The pleural cavity was irrigated with 1,500 c.c. of normal saline solution. Further exploration of lung and diaphragm showed no damage. How the bullet got to the lower abdominal area was undecided. Thoracotomy openings were closed airtight. The lung was expanded under positive pressure. A laparotomy was then performed and disclosed no intraperitoneal or retroperitoneal hemorrhage, and no diaphragmatic or viscus damage. The mystery was unsolved as to how the bullet had descended into the pelvis.

For one hour after the first severe hemorrhage at the outset of surgery the anesthetist was not able to detect the blood pressure. All anesthesia was stopped during this period, only oxygen being administered. At this time the patient appeared almost dead. Each labored respiration appeared to be his last. Following the operation, bronchoscopic aspiration and complete intercostal nerve block were done on right side.

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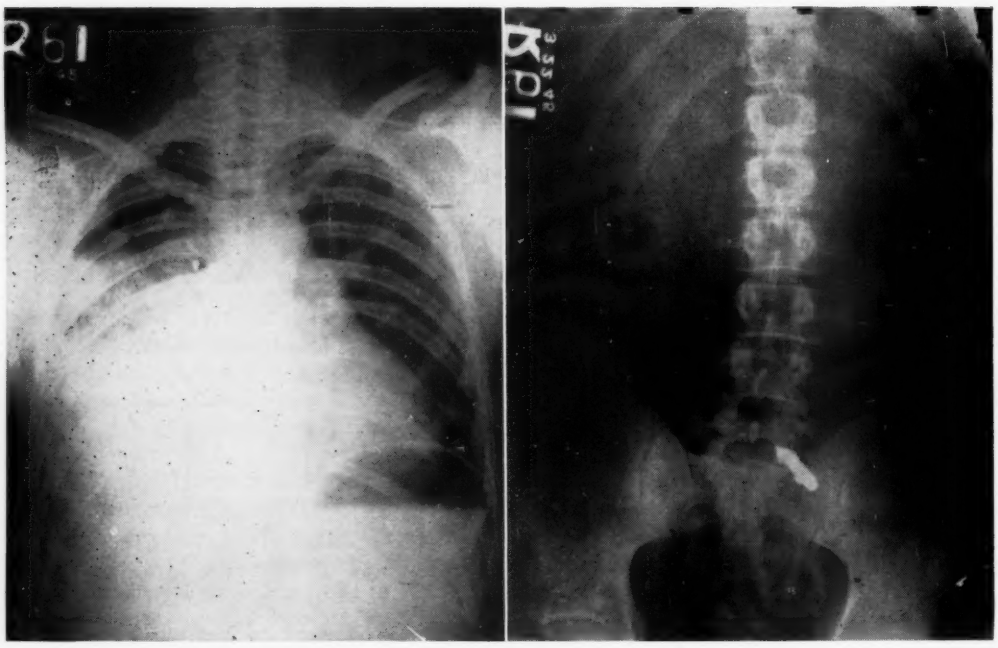

Fig. 1. Fig. 2.

Fig. 1.—Right hemopneumothorax with mediastinal shift to the left.
Fig. 2.—Position of machine-gun bullet on anteroposterior view of pelves.

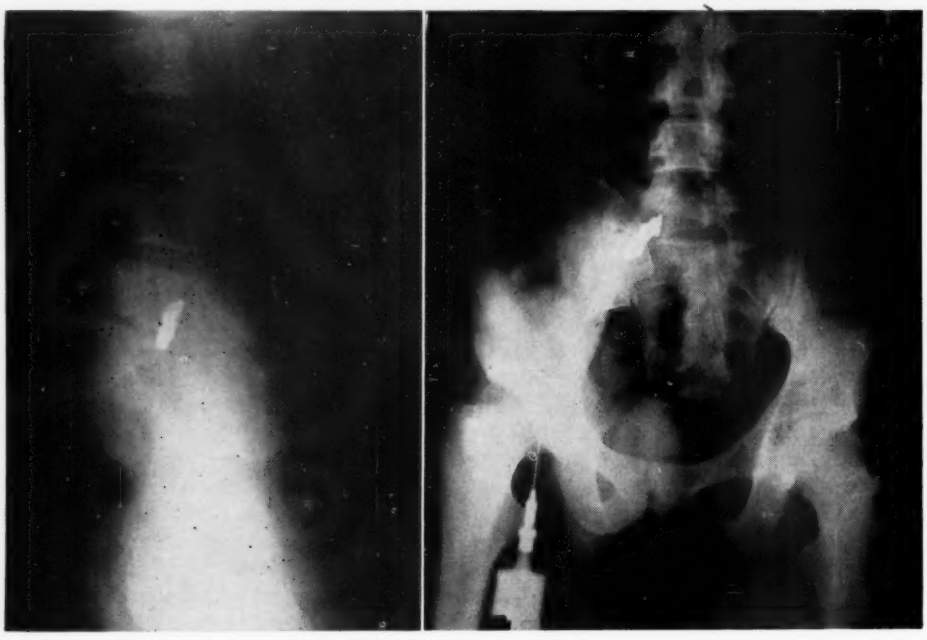

Fig. 3. Fig. 4.

Fig. 3.—Position of machine-gun bullet on lateral view of lumbar vertebrae.
Fig. 4.—Venogram, anteroposterior view, indicating position of bullet to be in left common iliac vein.

The total duration of surgery was two and one-half hours. During this period the patient received 2,500 c.c. of blood by two routes (arm and leg) simultaneously, under positive pressure a large part of the time. He received 500 c.c. of blood preoperatively and an additional 500 c.c. on the postoperative ward making a total of 3,500 c.c. of blood in about five hours' time.

Postoperative Convalescence.—Following operation the patient was very apprehensive for the first six or seven days, with a rapid pulse and respiration. Blood pressure never fell below 100 systolic and pulse pressure was always 40 or above. He received continuous nasal oxygen during this period, and daily venous pressure readings were made. Decompression with Wangensteen suction was used for first three days postoperatively. During the decompression period, 5 per cent glucose in saline solution was given to insure adequate urinary output and chloride balance.

Fig. 5.

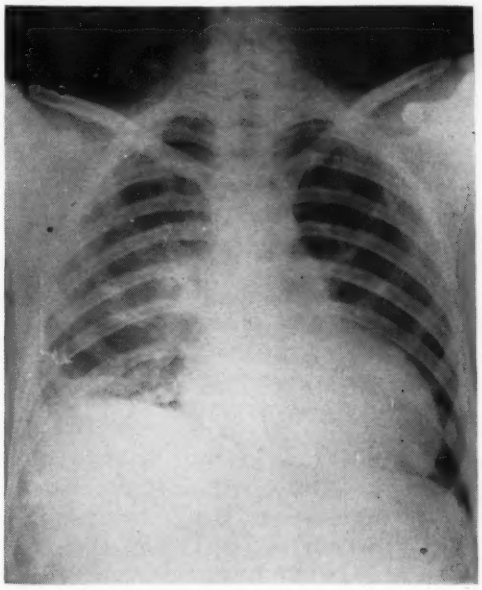

Fig. 6.

Fig. 5.—The patient three days after removal of missile (April 9, 1945).

Fig. 6.—X-ray view seventeen days after admission to field hospital (April 9, 1945); lungs have practically cleared.

The pericardial sac was aspirated on the second and third postoperative days with the following results:

March 24, 1945, 225 c.c. of sanguineous fluid were obtained. March 25, 1945, 65 c.c. of serosanguineous fluid were obtained. The highest venous pressure reading was 18.5 cm. of water. After the third postoperative day venous pressure was never above 14.5 cm. of water. Chest aspirations were performed according to radiographic findings. Frequent hematocrit readings were made and blood was given as indicated. Altogether the patient received 3,500 c.c. of blood during the postoperative course at the field hospital.

Penicillin was administered intramuscularly (25,000 U.) every three hours for twelve days following operation. A similar amount was given for six days following the last operation for removal of the foreign body. Vitamin therapy was administered from the beginning.

April 5, 1945, a venogram done by injecting diodrast in the left femoral vein indicated a machine-gun bullet in the left common iliac vein just below the bifurcation of the inferior vena cava (Fig. 4). Attempts to take a lateral venogram were unsuccessful.

April 6, 1945, under gas oxygen, ether anesthesia, a retroperitoneal exploration for the foreign body was performed. An elliptical incision was made just above and medial

to the left iliac crest. The left common iliac vein was exposed and tape was placed proximally and distally to the location of the missile. The occlusion of the vein wall above was done in the endeavor not to allow any clot to escape toward the heart. The vein was incised and a rather large amount of fibrinous exudate and blood clot attached to the bullet and vein wall was exposed and subsequently removed. The left common iliac vein was then ligated above and below the site of injury.

On the third day following the removal of the missile the patient was alert and his general condition was very satisfactory (Fig. 5). On the same day an x-ray view of the chest showed an enlarged cardiac shadow to the left. Lung fields were practically clear (Fig. 6).

Heparin was administered (one ampule a day for four days).

For the first three or four days following operation there was some pain and moderate swelling of the left thigh and leg which gradually subsided during the following seven days.

All incisions healed primarily except the anterior thoracotomy incision where the third rib was resected. This incision became secondarily infected and there was still slight seropurulent drainage when the patient was evacuated from the 33rd Field Hospital.

Personal communications from the patient during the postoperative course in base hospitals in Italy and at Walter Reed Hospital in Washington, D. C., indicated that his progress was satisfactory.

The following personal information was forwarded on Aug. 9, 1945, from Colonel R. A. Griswald, Chief of Surgical Service, Walter Reed General Hospital, Washington, D. C.:

"Your patient is at present here and was operated upon by me last week. When he got here he was in excellent condition with all wounds well healed, but had a large shadow on the left side of the heart with compression of the left ventricle as seen on diodrast angiocardiograms. Pictures with diodrast in the left ventricle showed that it was indented and compressed by this extracardiac mass which we thought was probably an encapsulated hematoma in the pericardium, since there was no fever, increased white count, or other signs of sepsis.

"I removed the left fifth costal cartilage and found that the mass was a thick walled, localized collection of pus in the pericardium. About 200 c.c. of pus was removed along with a piece of wool fabric about 1 cm. in diameter which was the cause of the abscess. Cultures were sterile. The location of the abscess was so far posterior that it had to be approached transpleurally. I unroofed it by removing a portion of the lateral abscess wall about 4 cm. in diameter so that it could drain adequately into the pleura. He is getting along well and should be out of the hospital within a few weeks."

Further communication from the patient revealed that he had an osteoperiosteal graft on March 8, 1946, at the Fitzsimmons General Hospital in Denver, Colo., to repair an anterior herniation of the chest wall, thus providing better heart protection. This operation was very satisfactory.

Editorial

The Society for Vascular Surgery

WITH an appreciation of the importance of vascular diseases of all types, and with a consequently increasing interest in such diseases, the establishment of The Society for Vascular Surgery attracts attention. During World War II the importance of peripheral vascular injury was particularly emphasized. As a result of exposure to cold, either on the damp ground, in the water, or in the air, changes in the peripheral vessels were frequent, some of only a temporary nature, whereas, others were so extensive that viability of the area supplied by the injured vessels could not be maintained. The need for additional investigation in such instances became evident. Although both traumatic and crymotic vascular injuries observed during the war were dramatic and attracted considerable attention and were responsible for calling attention to the importance of lesions of the vascular system, it must be emphasized that congenital and spontaneously occurring diseases of the vessels as well as traumatic lesions are of great importance during peace time. These conditions not only produce suffering and disability but also are likely to shorten materially the life span of the afflicted individual. Nothing could be more catastrophic or tragic than the sudden death from pulmonary embolism in a patient apparently normally convalescing from a simple operative procedure.

Advances in vascular disease can be made in a number of ways: clinical investigation of patients, noting the response of various therapeutic measures in the normal individuals and in those with vascular lesions. In many instances combined investigations by physiologists, pharmacologists, internists, and surgeons are necessary in order to understand the underlying pathology in vascular lesions and to evaluate the therapy. Also, much can be accomplished in the study of diseases of the vascular system as well as in other diseases by animal experimentation. It is becoming increasingly more apparent that in large hospitals vascular services should be established in order to permit these combined studies. In this way the patient with vascular disease, whether spontaneously occurring or whether the result of trauma or other causes, will receive better care.

Dr. Geza de Takats, who is recorder for the new society, has summarized the objectives of the society as follows: (1) to promote research and study in vascular disease; (2) to define more clearly the role of surgery in this field; (3) to promote and encourage adequate teaching of vascular diseases to students, interns, and residents; (4) to encourage hospitals to develop special sections in vascular surgery and to provide special training in vascular surgery for young surgeons interested in this field; (5) to pool the experiences and knowledge of

the members of this society in order to obtain more standard methods of study and management of vascular diseases; (6) to standardize terminology or nomenclature of vascular diseases; (7) to hold annual meetings.

With the increasing span of life, the importance of degenerative changes within the vascular system become greater. Although in the past it has been generally accepted that in older persons ischemia and ablation of an extremity are frequently inevitable, because of the degenerative vascular changes, it is possible and even probable that this pessimistic outlook is not necessary and it is hoped that investigations stimulated by the newly formed society may result in the saving of more extremities.

The first meeting of the society will be held in Atlantic City immediately preceding the annual session of the American Medical Association and all members of the medical profession interested in lesions of the vascular system are cordially invited. Unquestionably, because of the interest in this new field and because of the society's potentialities, the meeting will be a success.

—*Alton Ochsner, M.D.*
New Orleans, La.

ANNOUNCEMENT

The Fourth International Cancer Research Congress

The Fourth International Cancer Research Congress will be held in St. Louis, Mo., Sept. 2 to 7, 1947. The Union Internationale Contre le Cancer having accepted the invitation of the American Association for Cancer Research, the Congress will be held under the joint auspices of these two organizations, with Dr. E. V. Cowdry, Professor of Anatomy, Washington University School of Medicine and Director of Research of the Barnard Free Skin and Cancer Hospital, serving as president of the Congress.

Of the three Congresses that have been held previously, the first was in Madrid, Spain, in 1933; the second in Brussels, Belgium, in 1936; the third in Atlantic City, New Jersey, U. S. A., in 1939. Due to the recent war, there has been no meeting of the Congress during the past eight years.

The State Department in Washington having approved of the International Cancer Research Congress, official invitations soon will be sent to all foreign governments who are to send delegates.

Initial steps in the organization of the Congress have been completed, in that all officers and committees have been appointed and are enthusiastically at work. In addition to the president, Dr. E. V. Cowdry, Dr. J. Godard, president of the Union Internationale Contre le Cancer, and Dr. W. U. Gardner, president of the American Association of Cancer Research, will serve ex-officio as members of the Executive Committee.

The following Committee personnel have accepted Chairmanships: A. N. Arneson, St. Louis, Mo., Local Arrangements; S. Bayne-Jones, New Haven, Conn., Finance; C. W. Larimore, New York, N. Y., Exhibits; L. A. Scheele, Bethesda, Md., Governmental Liaison; M. G. Seelig, St. Louis, Mo., Publicity; Shields Warren, Boston, Mass., Program.

Headquarters will be at the Hotel Jefferson, St. Louis, where some three hundred rooms will be available for guests. In addition to these rooms, other nearby St. Louis hotels have signified a willingness to make reservations on advance notification by those contemplating attendance at the Congress.

Book Reviews

Peripheral Vascular Diseases. By Edgar V. Allen, B.S., M.A., M.D., M.S., F.A.C.P., Divison of Medicine, Mayo Clinic; Nelson W. Barker, B.A., M.D., M.S., F.A.C.P., Division of Medicine, Mayo Clinic; Edgar A. Hines, Jr., M.D., B.S., M.A., M.S., F.A.C.P., Division of Medicine, Mayo Clinic; and associates in the Mayo Clinic. Pp. 871, with 386 illustrations. Philadelphia, 1946, W. B. Saunders Company. $10.

This is a comprehensive treatise and in the reviewer's opinion the best of the several books on the same subject which have been published during the past few years. The three principal authors are recognized authorities in their field and have a combined experience to draw from which is unsurpassed anywhere. Eleven other contributors have written portions of the book which deal with specialized phases of the subject and give a uniform excellence to the whole book.

Each disease is considered as an entity. The student will find much pertinent knowledge concerning the history and methods of investigation of each subject. The practitioner will find adequate sections on diagnosis and treatment. The teacher will find it an excellent reference book. The bibliography is well chosen and adequate.

The work is dedicated to the late George E. Brown of the Mayo Clinic. In the reviewer's opinion the hope of the authors has been fulfilled. It is a worthy monument.

Harvey Cushing, a Biography. By John F. Fulton. Pp. 754, with 89 illustrations. Springfield, Ill., 1946. Charles C Thomas, Publisher.

In his will, Cushing made provision for the publication of his biography should it be deemed "of interest and help to medical students." Fulton has more than met these conditions, and has edited and integrated a vast body of source material which he has bound together with an easy-flowing narrative. Written and composed in the manner of Cushing's "Osler," to which it is a worthy companion piece, the author has selected liberally, but critically, from Cushing's prolific and illuminating diaries, correspondence, and publications.

With just enough family, geographic, and genealogic background, the biography passes quickly through his youth, pauses a little longer in the "bright college years" at Yale, and settles down to a sustained pace with his entrance into Harvard Medical School and early years at the Massachusetts General Hospital. The picture emerges of Cushing, a restless spirit "hot to the touch," consecrated to medicine, fired by a tremendous ambition, and sustained by boundless energy. Through the medium of his diary and family correspondence is presented an account of medicine and surgery in Boston in the days of the amphitheatre and private home, of surgical Titans and the hazards of anesthesia.

Then follow, in sharp contrast, his life as surgical resident at the Johns Hopkins, but newly sprung from the brow of Aesculapius, the interesting development of his relations with Halsted, his sustained friendship with Welch, and the beginnings of all-important relations with Sir William Osler, who led him "on the severe ascent of high Parnassus." Following his year of study abroad with Kocher, Kronecker, and Sherrington and the widening of his outlook to an international horizon, so important to his later development, there is the return to Baltimore—the "latch-keyer" days—the ripening of his surgical thinking, contributions to surgical technique and its teaching, and the gradual development of the relatively unexplored field of neurologic surgery. This part of the book, closing with a record of his negotiations with Harvard which led to the Moseley Professorship and the Brigham Hospital, is particularly well done, and shows the breadth of Cushing's surgical foundation.

After a most interesting account of settling in Boston and at Harvard, there follows the narrative of the war years, taken largely from his Homeric diary which serves to project Cushing against the background of the war. In the years that follow, we find H. C. back at Harvard. These are years of intense and tremendously varied activity, years of promise fulfilled, punctuated by a steady stream of honors in this country and abroad. By choice, references to the more technical phases of these clinical years have been deliberately curtailed in favor of historical and personal material.

The closing chapters deal with Cushing's return to Yale, a period rich in literary accomplishment, but tempered somewhat by ill health and forced inactivity. Much time was spent in the arrangement and disposition of his books, in writing, and in the preparation of the biobibliography of Vesalius, a work which he did not quite have time to finish. In 1939, his 70th birthday was celebrated with a tremendous expression of affection and esteem, and shortly thereafter he received the unique honor of election to the Royal College of Physicians. Later that year, in the Fall, he succumbed to a coronary occlusion.

The book cannot fail to inspire and stimulate medical students, but even more than that, it is the record of a great figure and personality during the coming of age of surgery in America. Well illustrated and profusely documented, it is easily written and objective to a high degree, although the inclusion of many of Cushing's facile sketches and the numerous quotations give the book almost the character of an autobiography. As Cushing was a man of such broad interests and attainments, the volume should have a wide general appeal; as a personal record of his contemporaries, and as a commentary on his times, it should prove of lasting interest and real significance.

Operative Gynecology. By Richard W. TeLinde, M.D., Professor of Gynecology, Johns Hopkins University, Baltimore, Md. Pp. 725, with 318 illustrations. Philadelphia, 1946, J. B. Lippincott Company.

TeLinde, who heads the department of gynecology at Johns Hopkins Hospital and Medical School, has prepared this book for use particularly by graduate students during specialty training and as a reference book for clinical work for general surgeons. It is also of interest to the specialist. It is not a reference book but presents in detail the methods in use in his own department and the reasons for their adoption. It is, then, a most practical presentation and will receive wide acceptance for this reason.

Detailed consideration is given to pre- and postoperative study and care. In particular, the Hopkins routines for the handling of the bladder after pelvic surgery are discussed at length and the results are reported to be really excellent.

The indications and contraindications of most of the useful gynecologic surgical procedures are presented clearly and soundly. Surgical techniques are given in detail and clearly. One is surprised at the absence of descriptions of techniques for local anesthesia and of the Wertheim operation. The two paragraphs dealing with the details of the x-ray therapy of cervical carcinoma are in need of revision.

The illustrations are magnificent and in most generous number. They have been produced by a number of artists. They might well serve as standards of excellence toward which others might strive.

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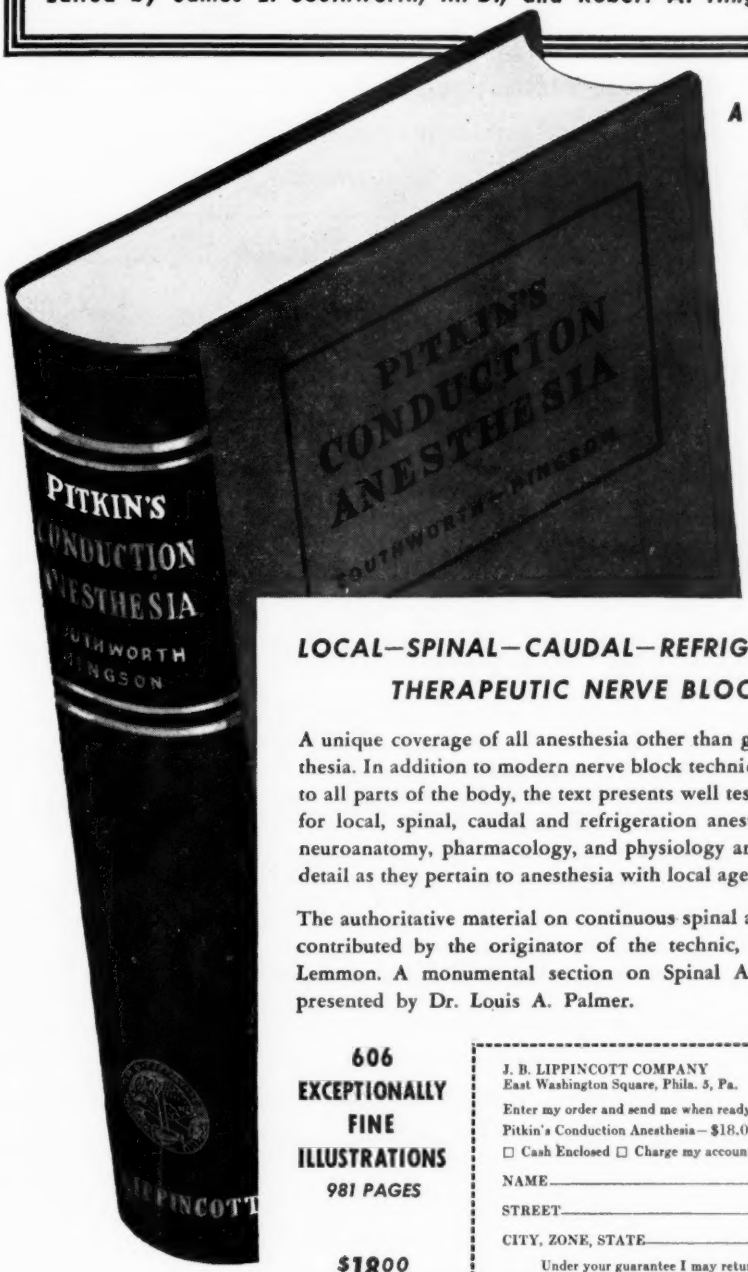

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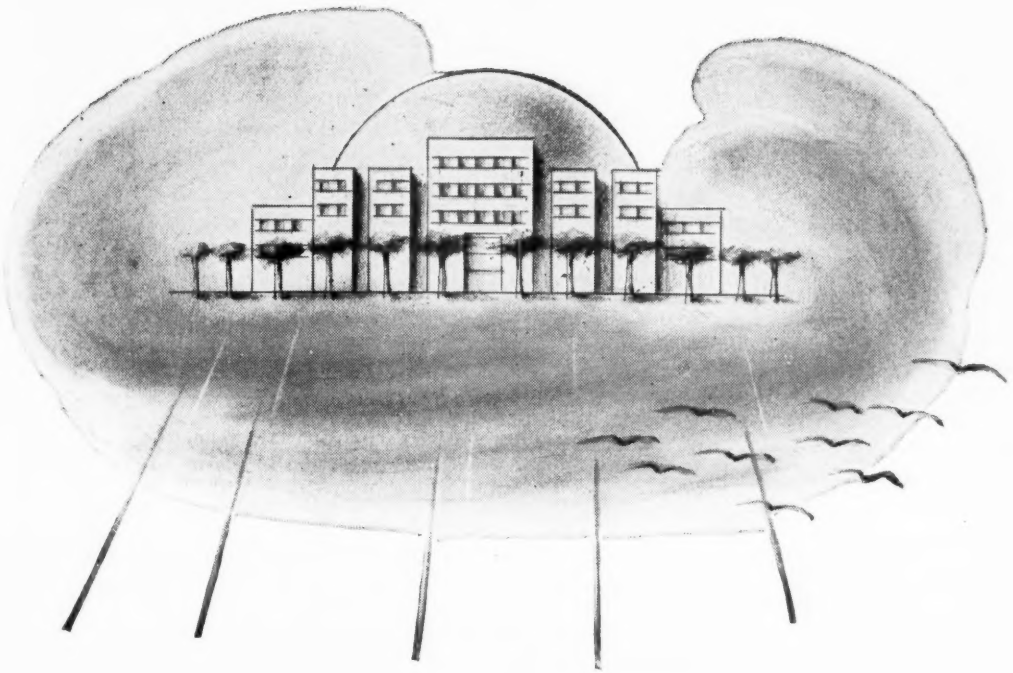

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